THE ENGINEER

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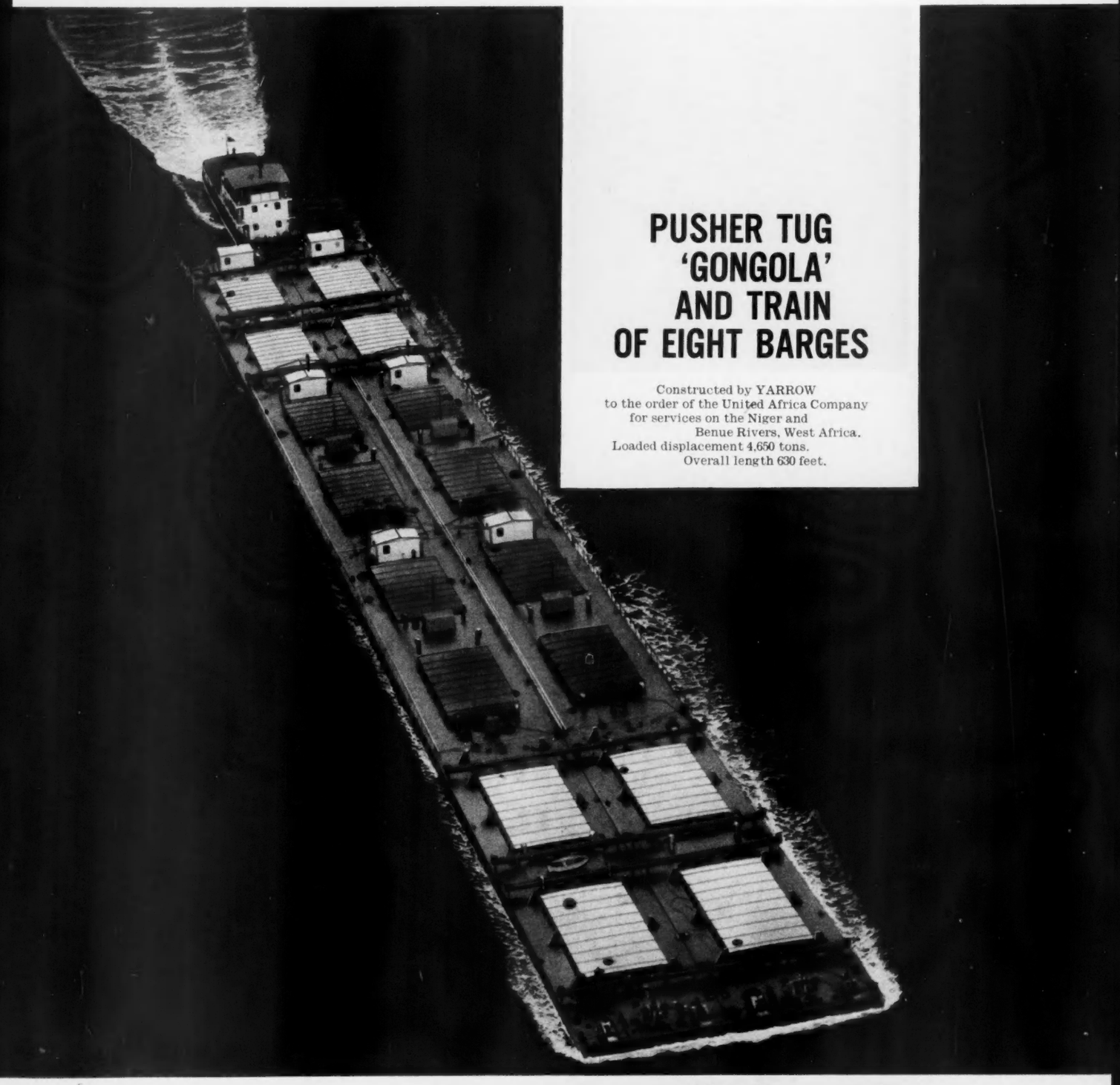

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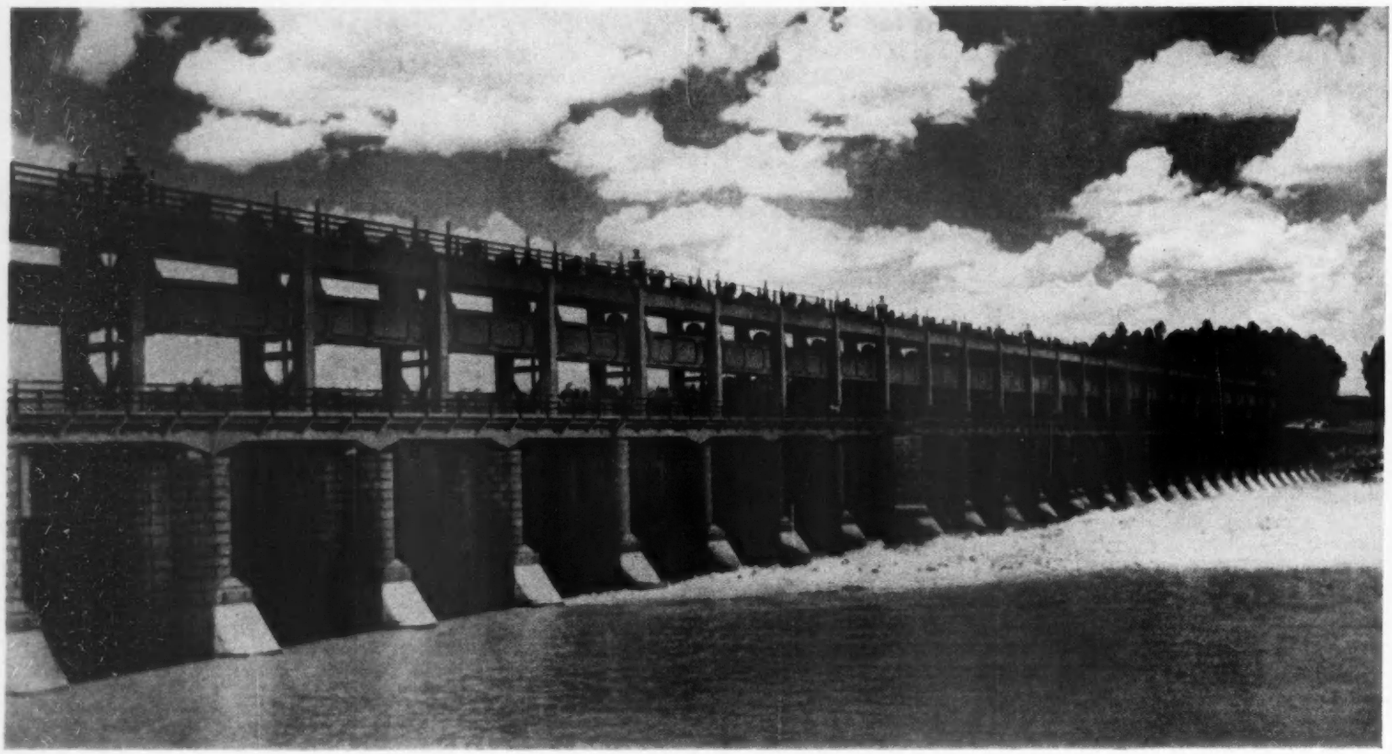

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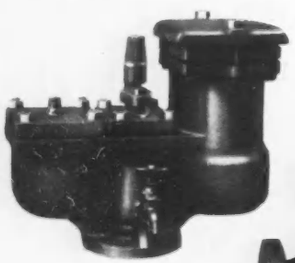

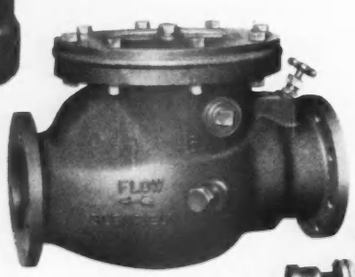

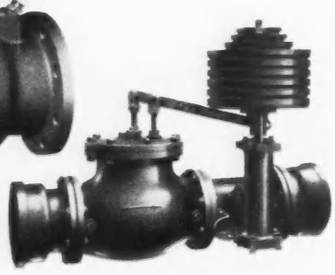

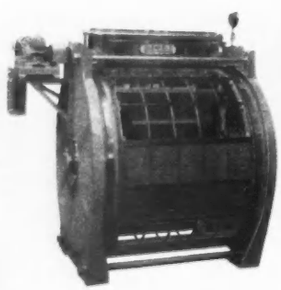

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Established 1856

No. 5384 APRIL 3, 1959 VOL. 207

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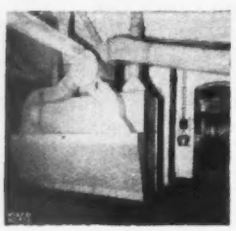
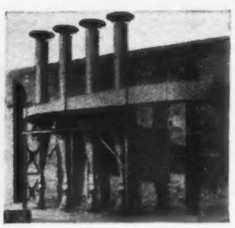
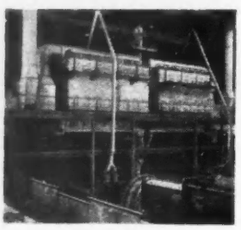

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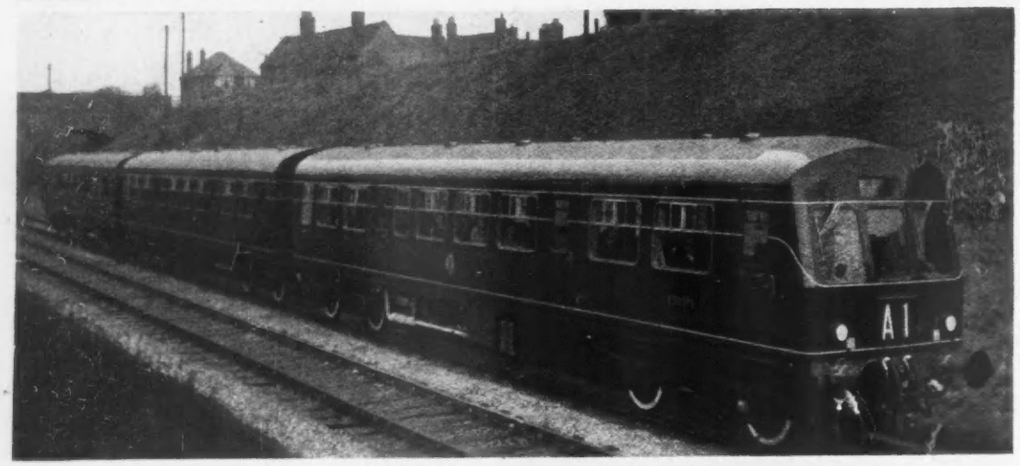

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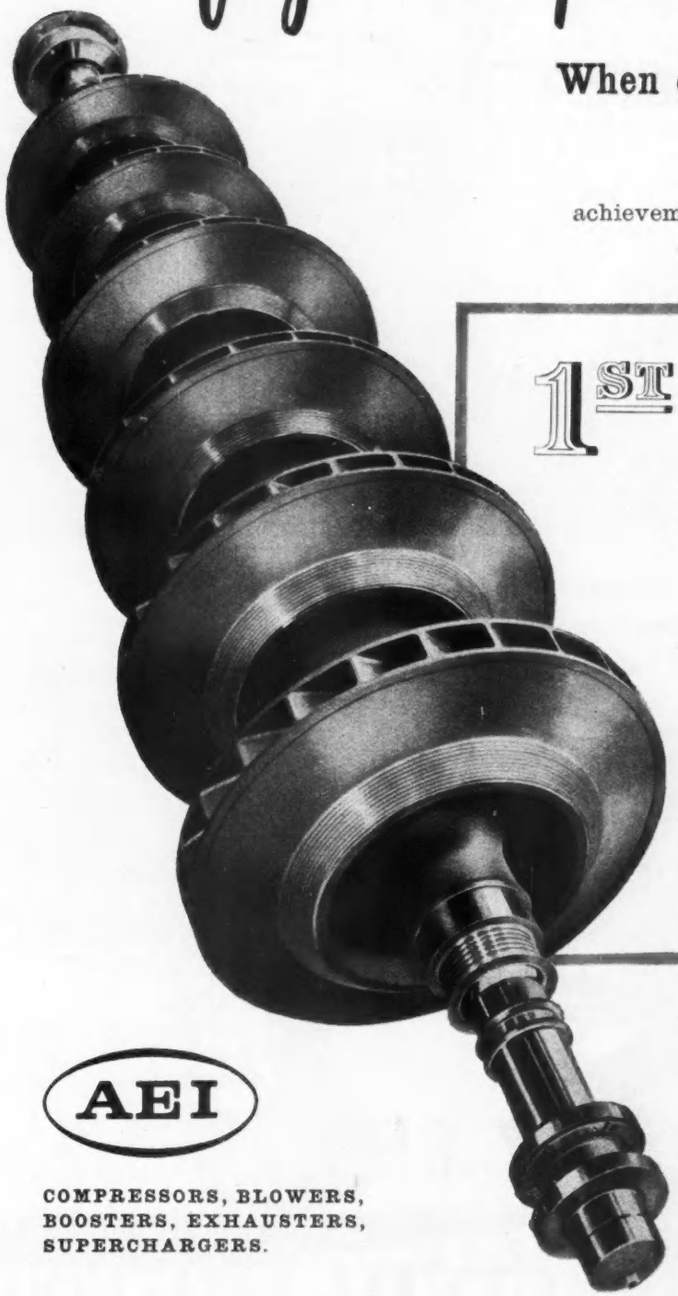

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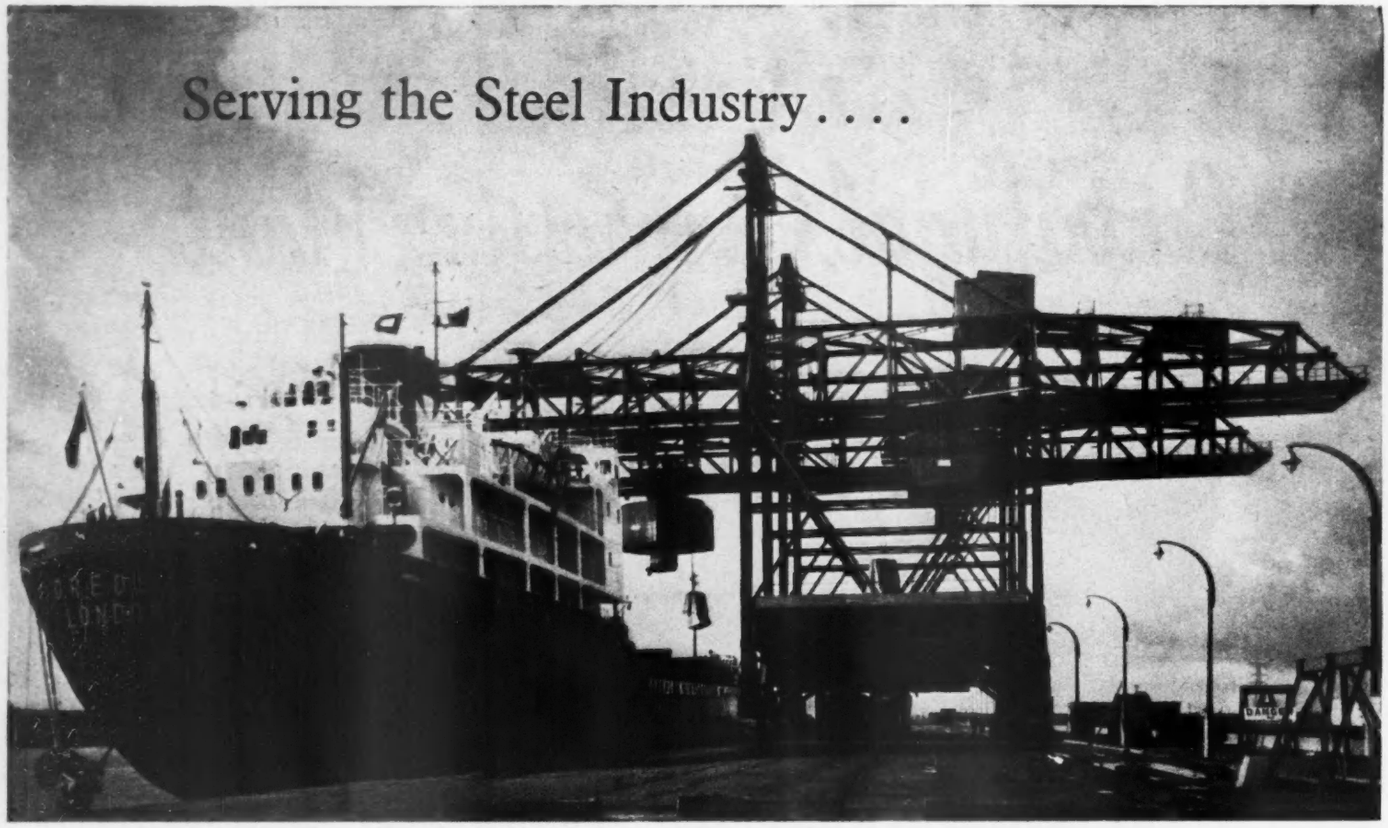

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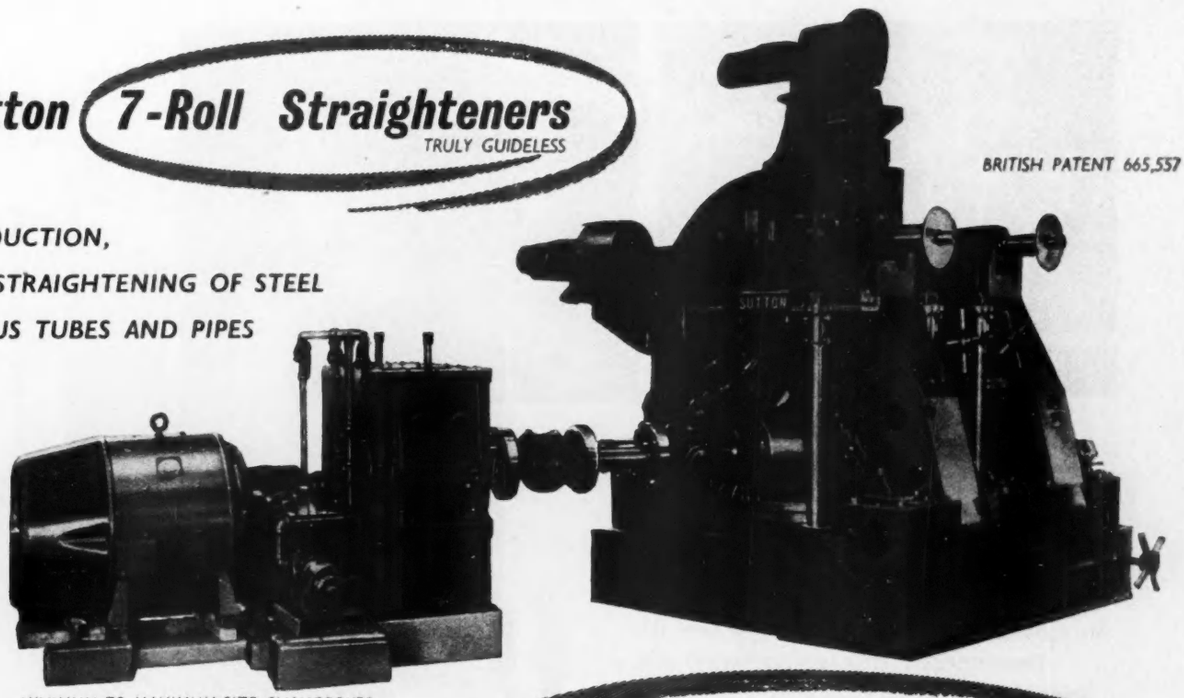

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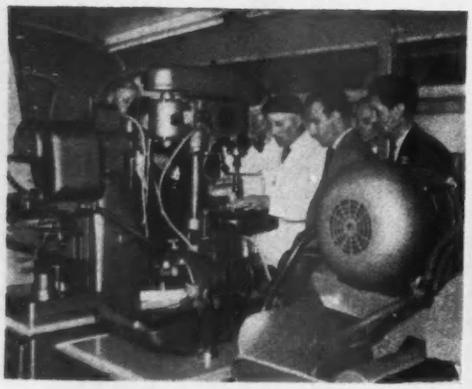

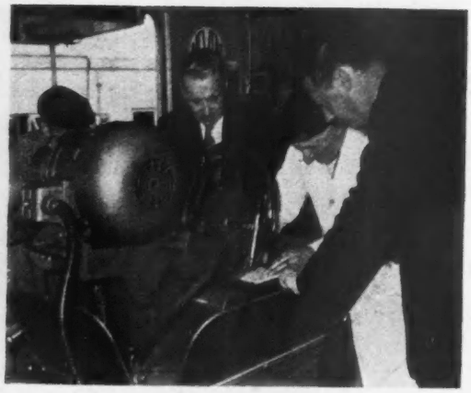

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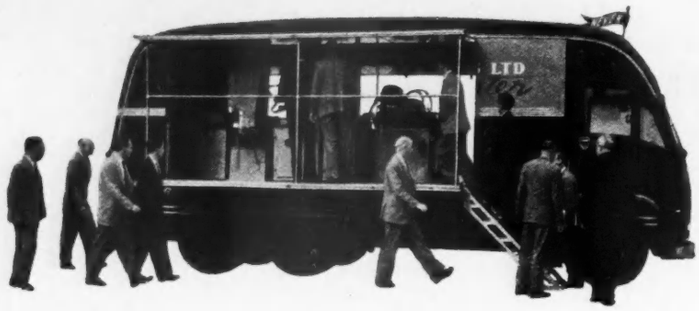

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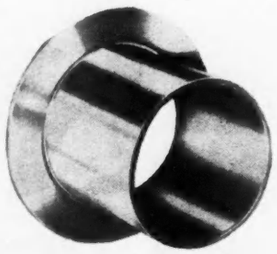

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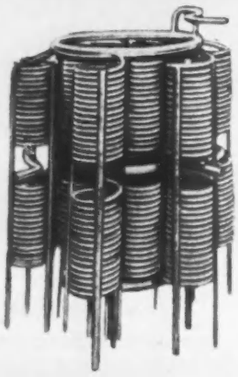

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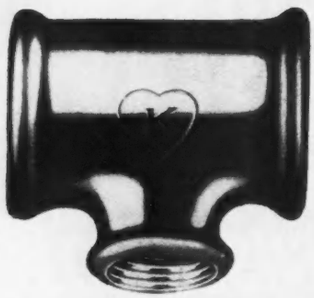

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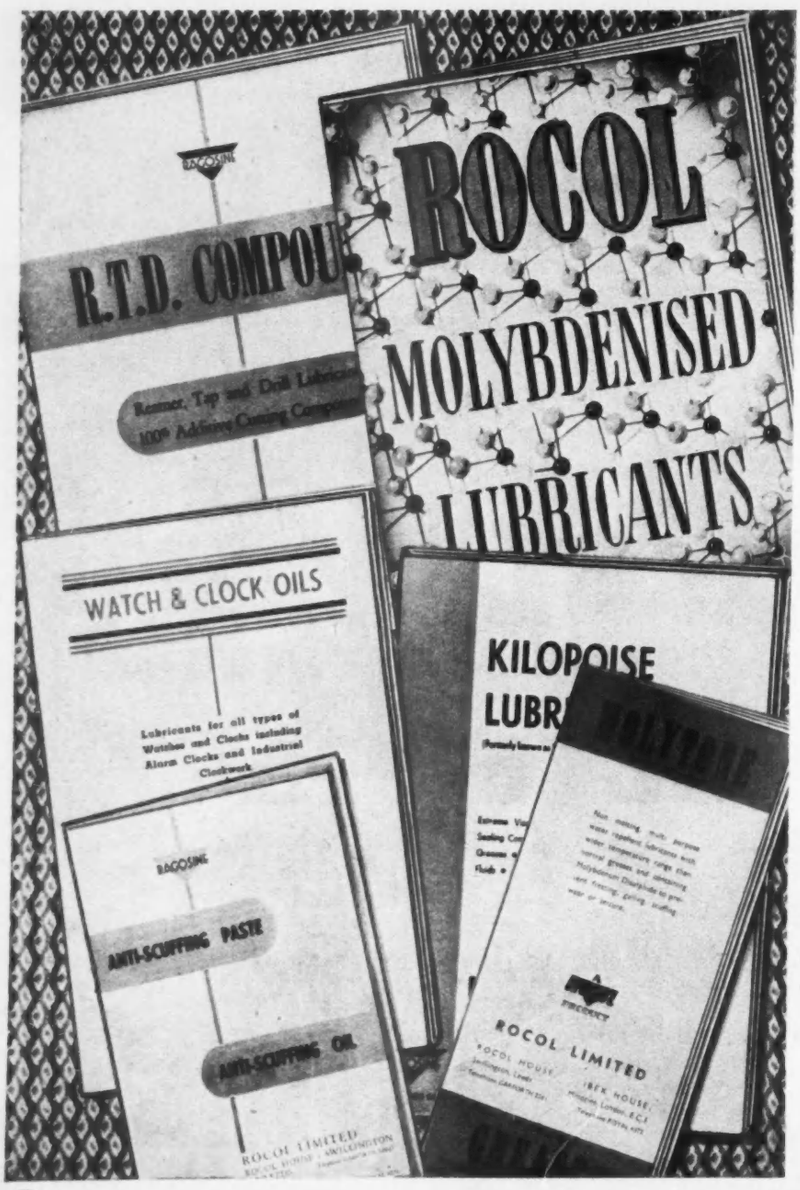

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The photograph shows one of the many types of Saunders Valves in use in industry.

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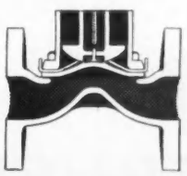
The sectional view shows the resilient diaphragm in the Saunders Valve. The excellent temperature stability of silicone rubber diaphragms enables these valves to be used for conveying gases and chemicals at extremes of temperature.



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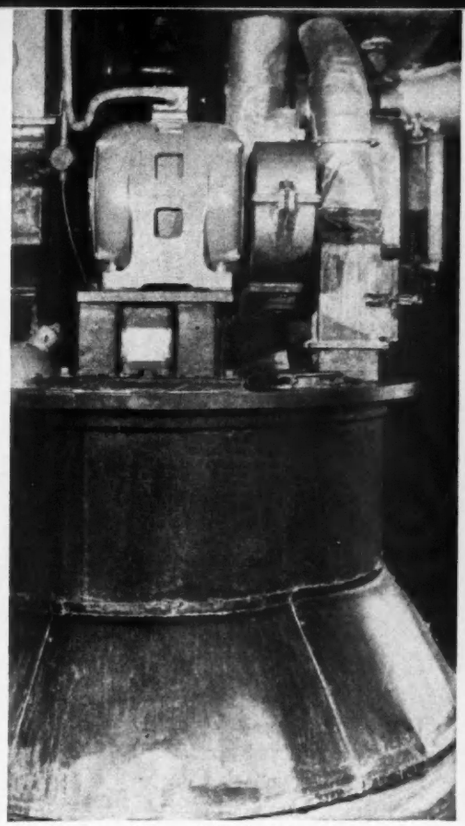

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Thomas Hedley & Co. Ltd., at the company's West Thurrock factory, found that one of their motors working in a particularly wet position, on a mixing tank used in the manufacture of synthetic detergents, broke down at average intervals of 6 months. Rewinds were tried in Class A insulation (costing £30 each time), and in Class B insulation with extra varnish dips to give additional protection against moisture – both without success. Finally they tried a silicone rewind. This was nearly seven years ago and the motor has been operating since without failure, thus saving approximately £400 in rewind costs. In addition losses in production time due to motor failure have been eliminated.

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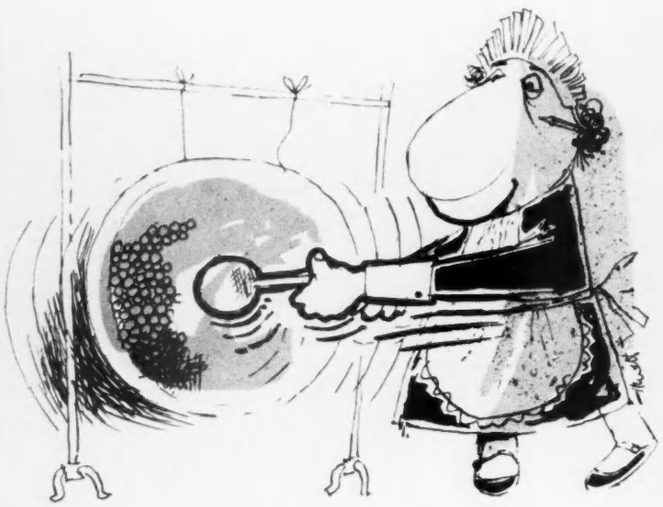
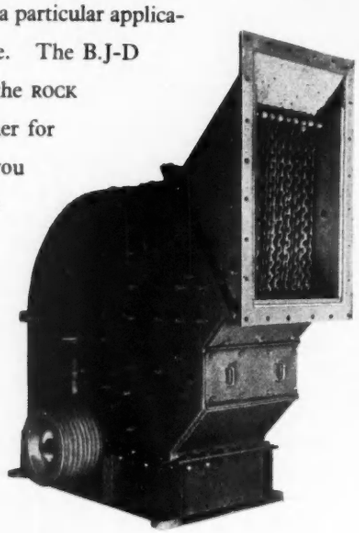


On making an impact

THE impact of a soft hammer on a gong merely produces sound waves. On the other hand, the rotating hammers of a B.J-D Impact Crusher produce valuable, tangible results. There's a wide range of these machines, designed to reduce all kinds of industrial materials to required sizes. B.J-D, with many years' experience in this field, are usually able to offer just the right crusher for a particular application, even if it is an unusual one. The B.J-D machine shown on the right is the ROCK BUSTER, a powerful impact crusher for friable rock, pit shale, etc. If you have a crushing problem, B.J-D experience is freely at your disposal. Call us in!



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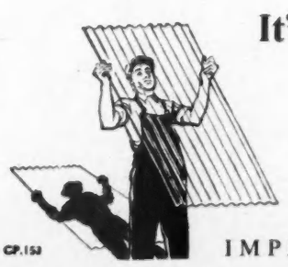

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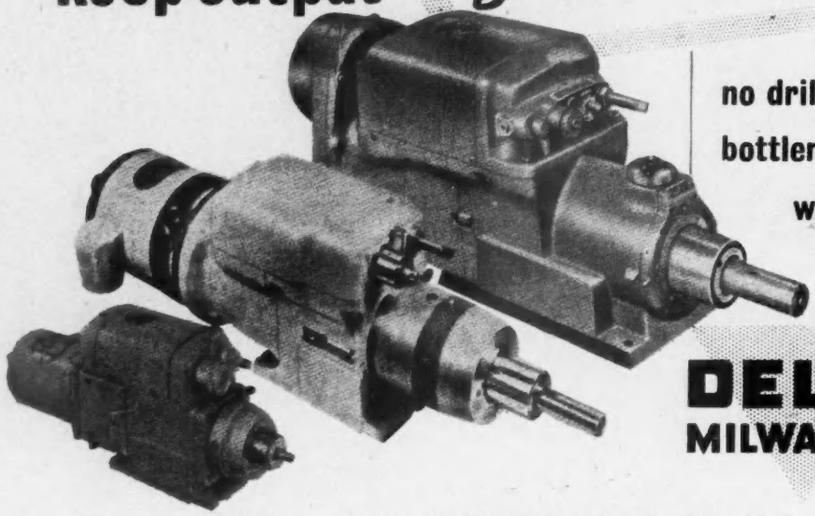

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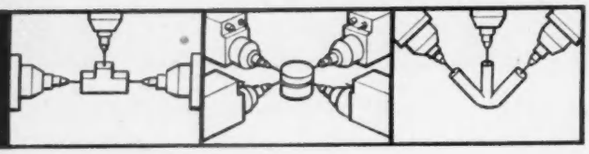

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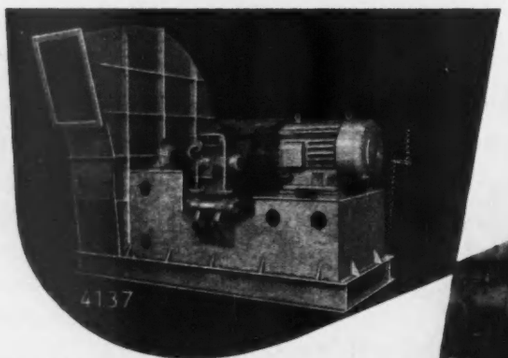

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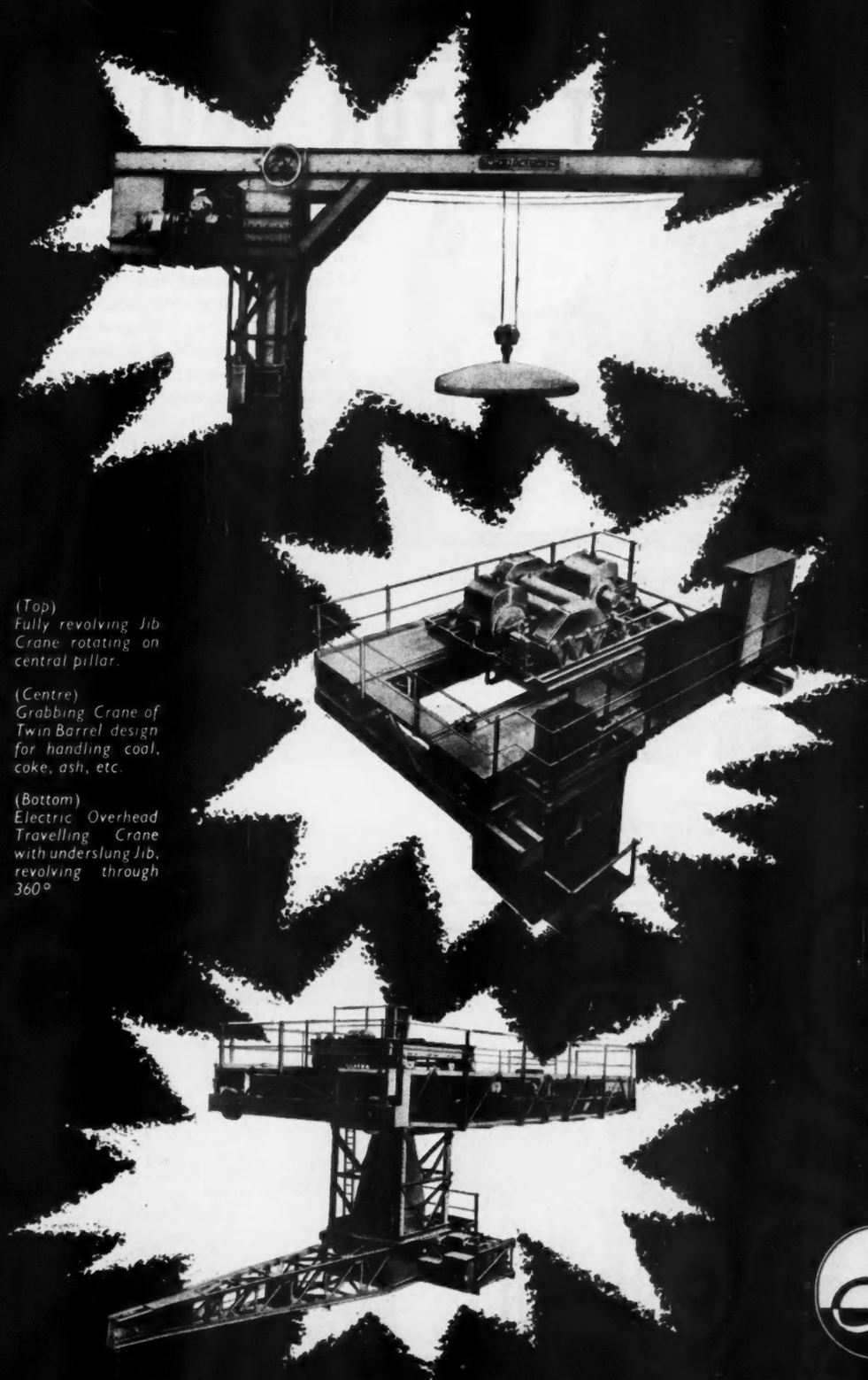

(Top)
Fully revolving Jib Crane rotating on central pillar.

(Centre)
Grabbing Crane of Twin Barrel design for handling coal, coke, ash, etc.

(Bottom)
Electric Overhead Travelling Crane with underslung Jib, revolving through 360°

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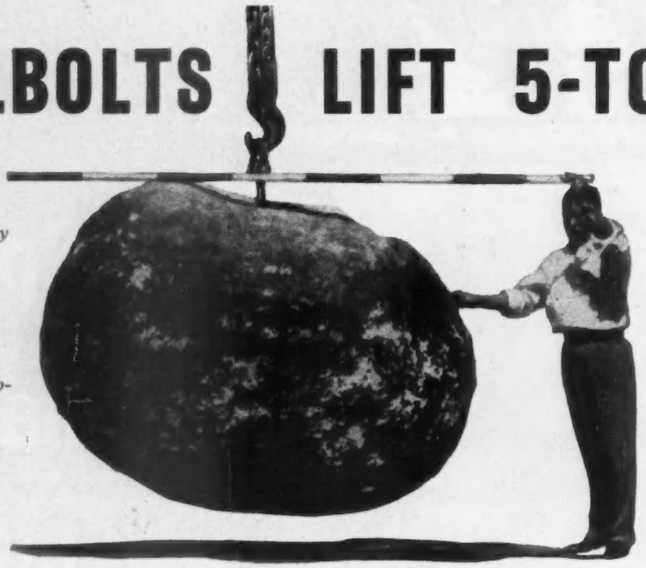
RAWLBOLTS LIFT 5-TON BOULDERS



We are indebted to Messrs. George Wimpey & Co. Ltd., the Building and Civil Engineering Contractors for the information. The photograph was kindly provided by Mr. Howarth from the North Point Generating Station, Hong Kong.

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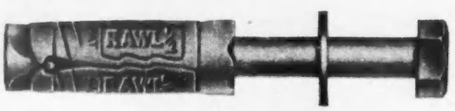
RAWLBOLTS



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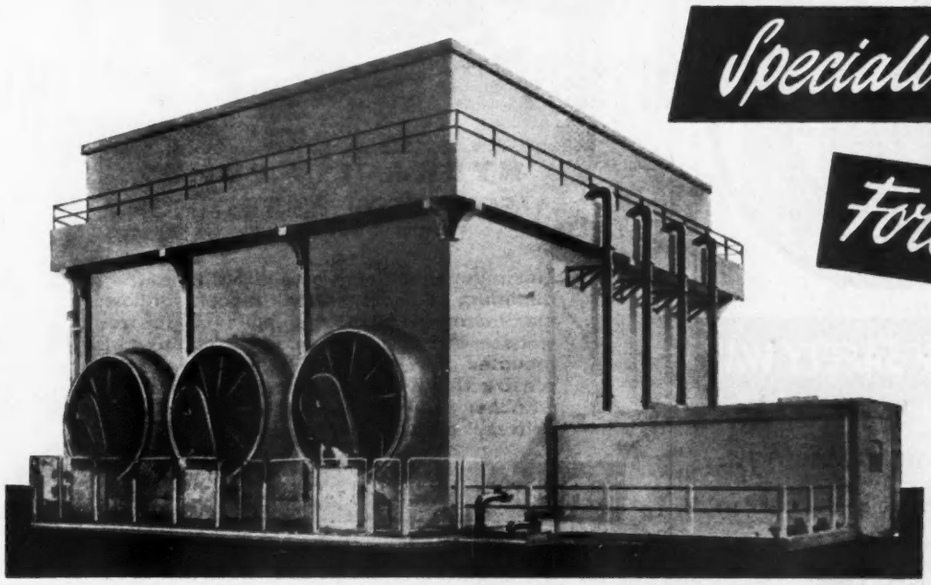

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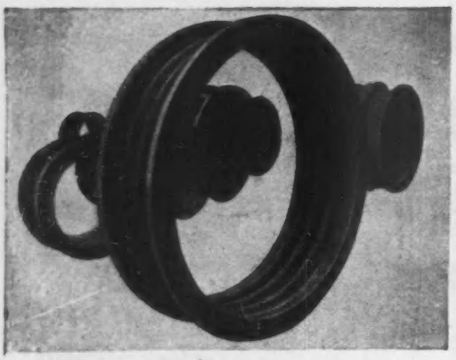
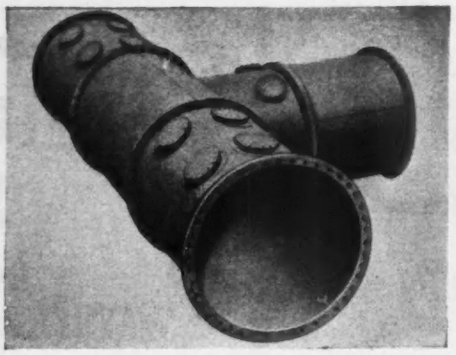
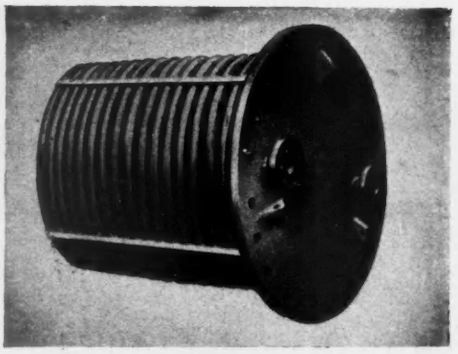

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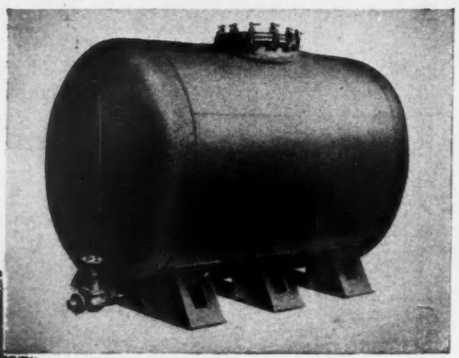

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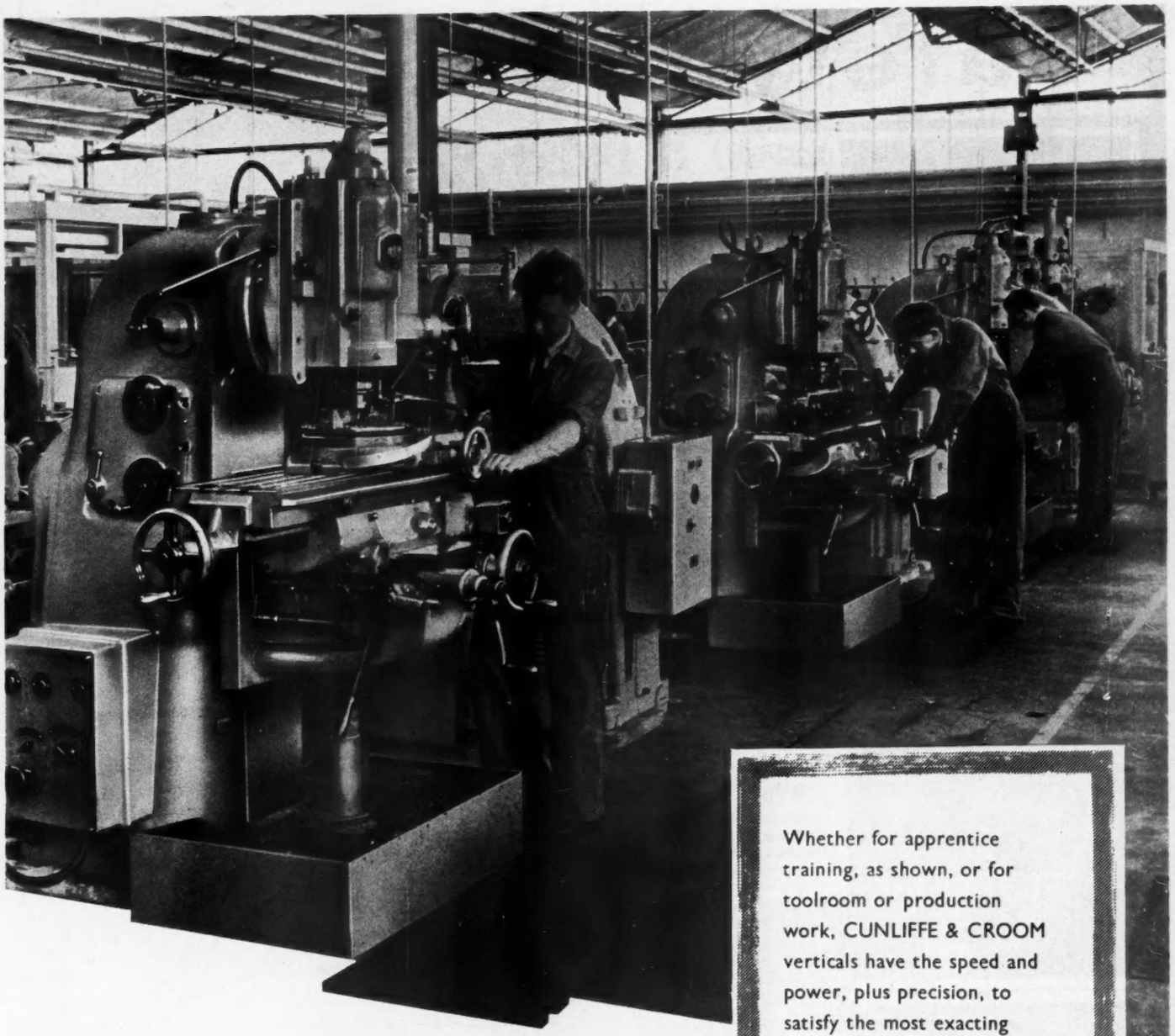

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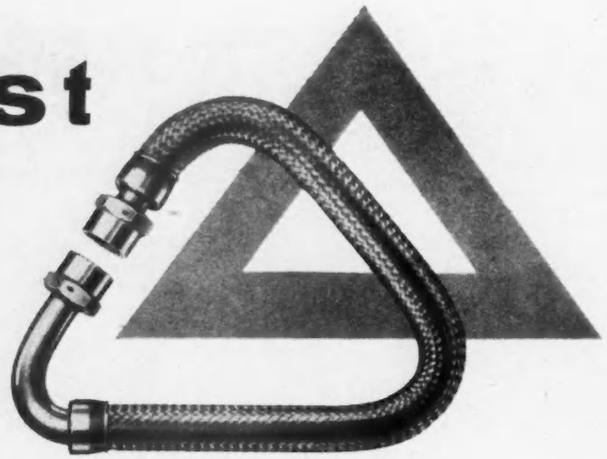

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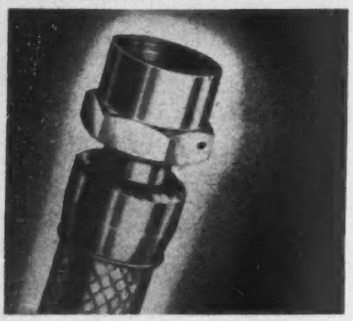

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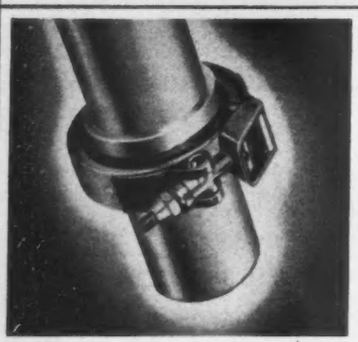

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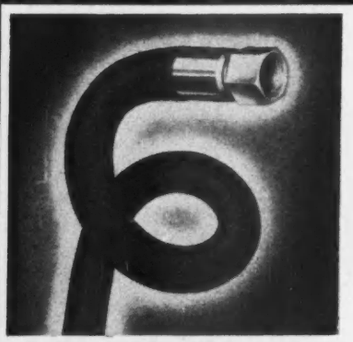

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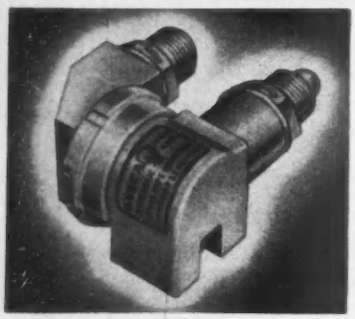

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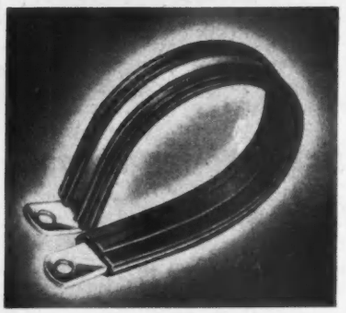

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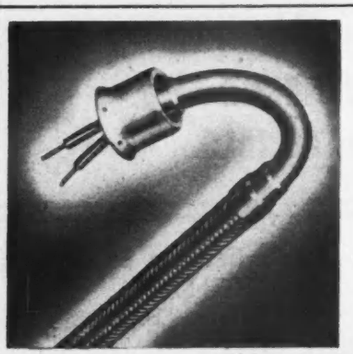

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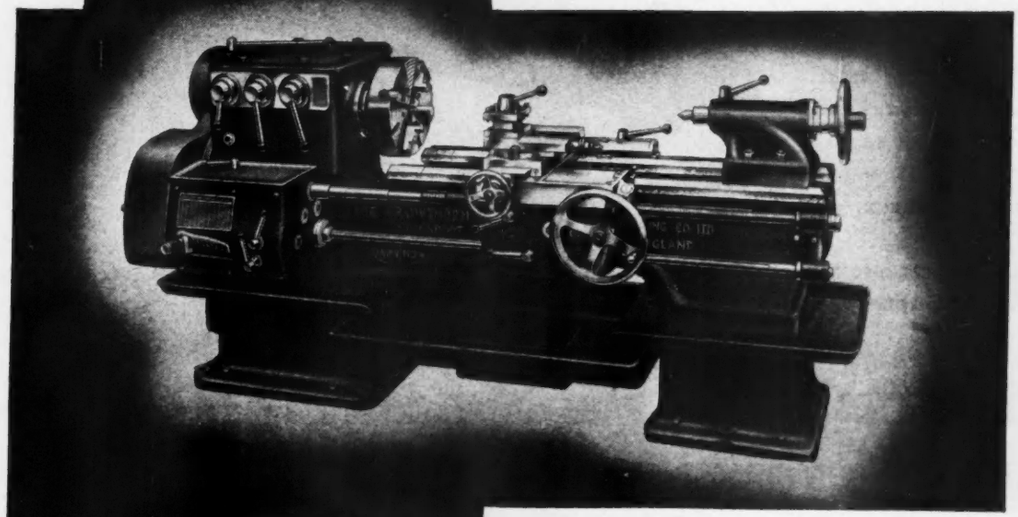

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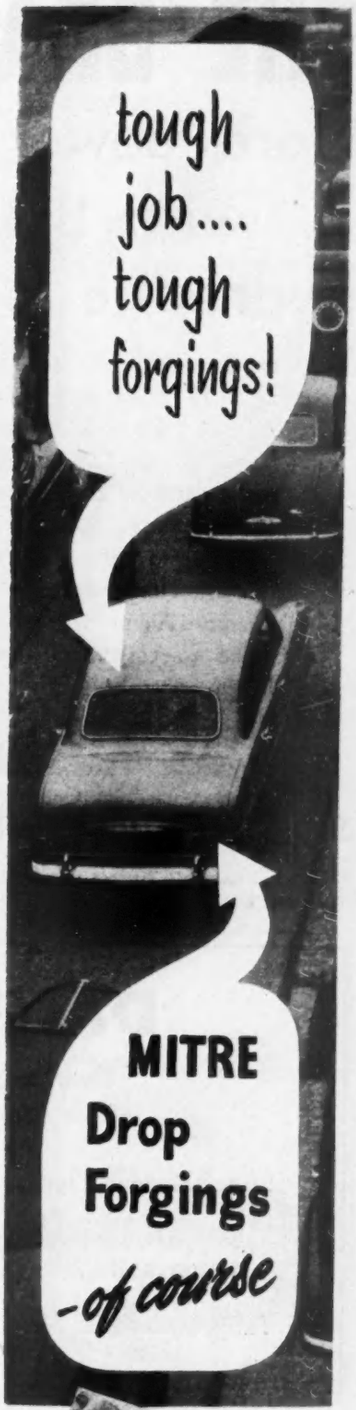

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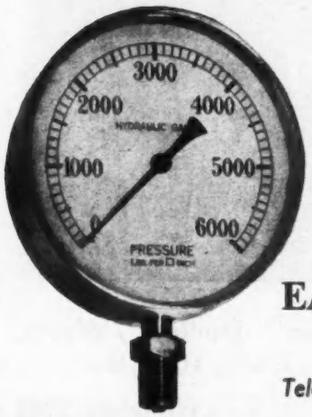

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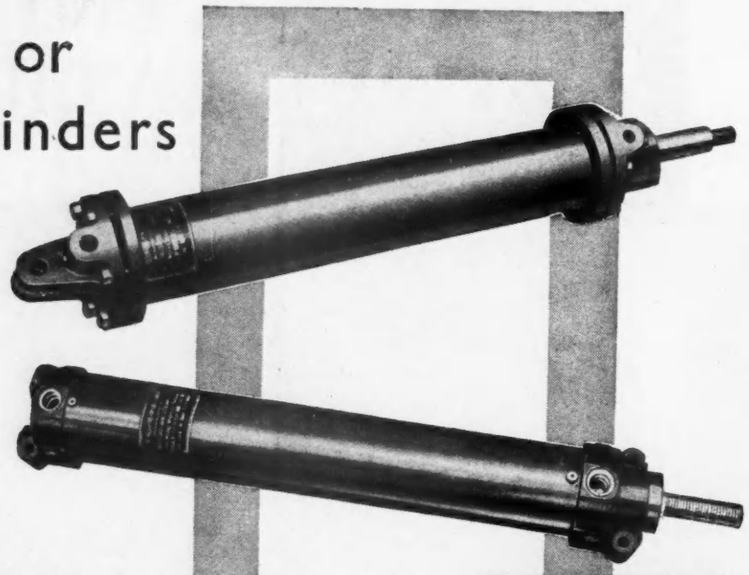

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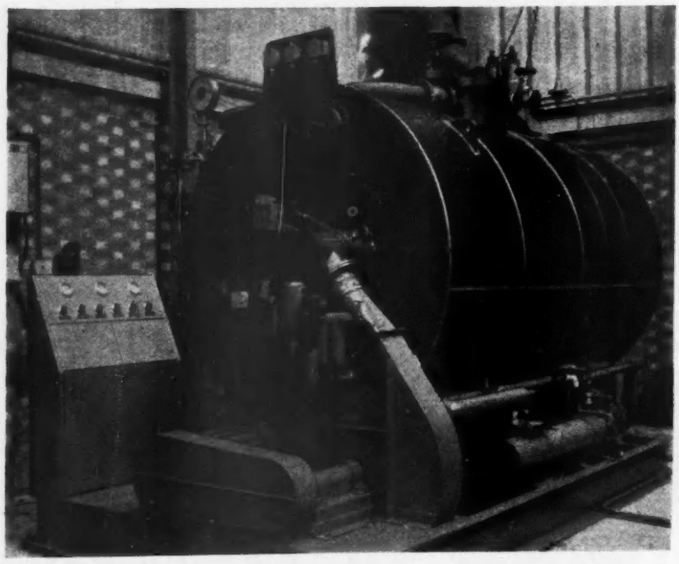

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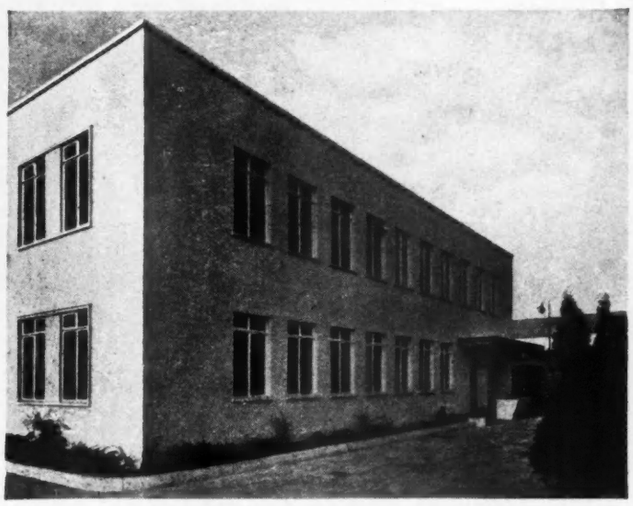

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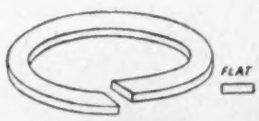

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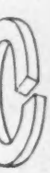

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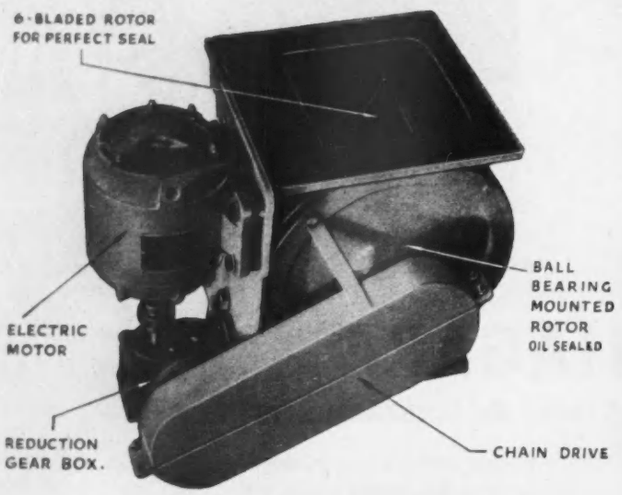

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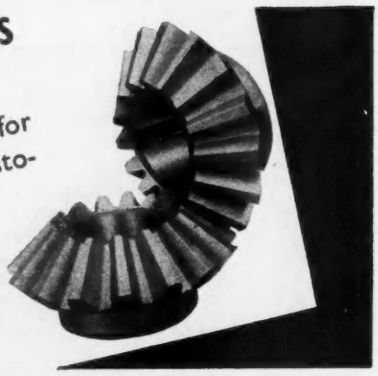

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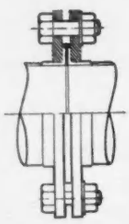

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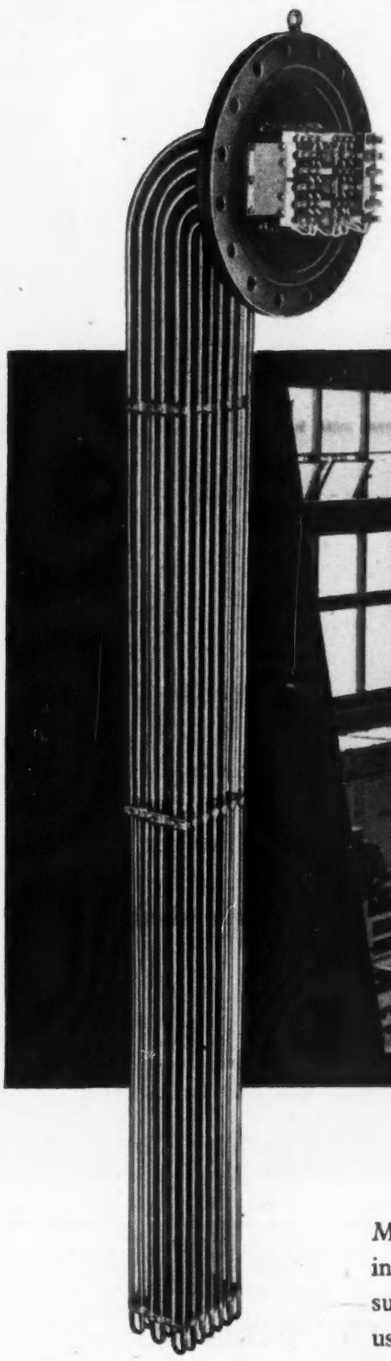

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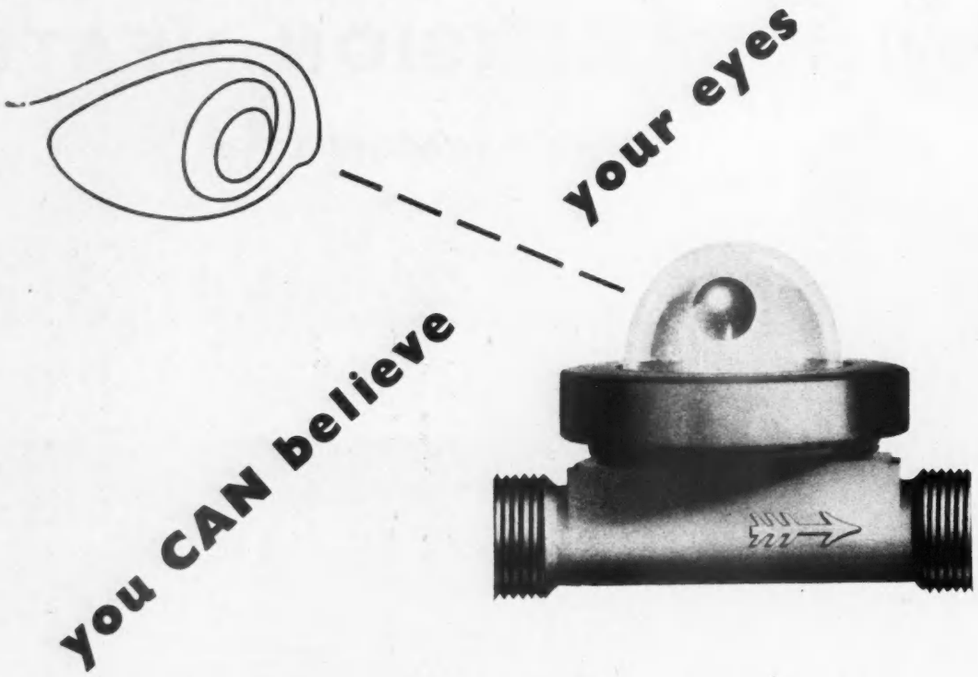

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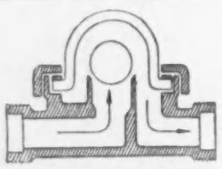

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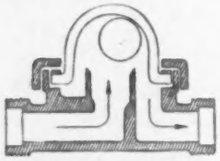

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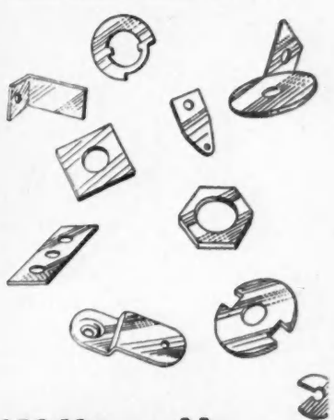

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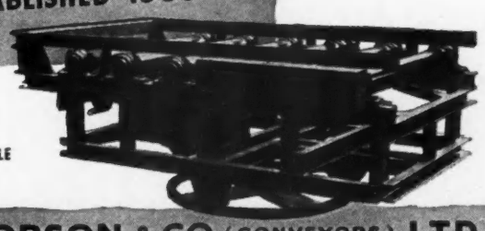

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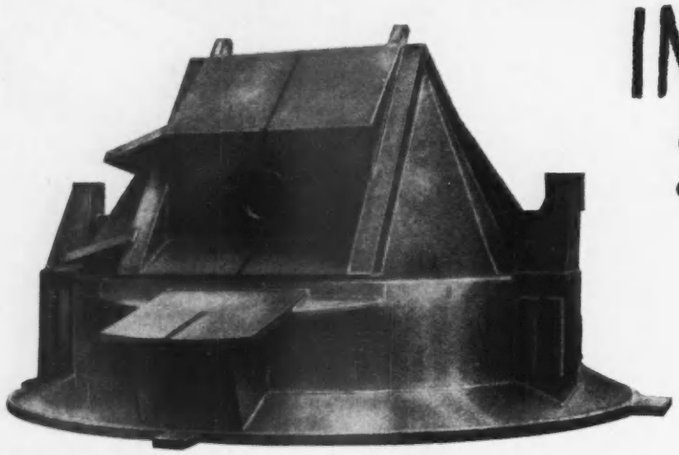

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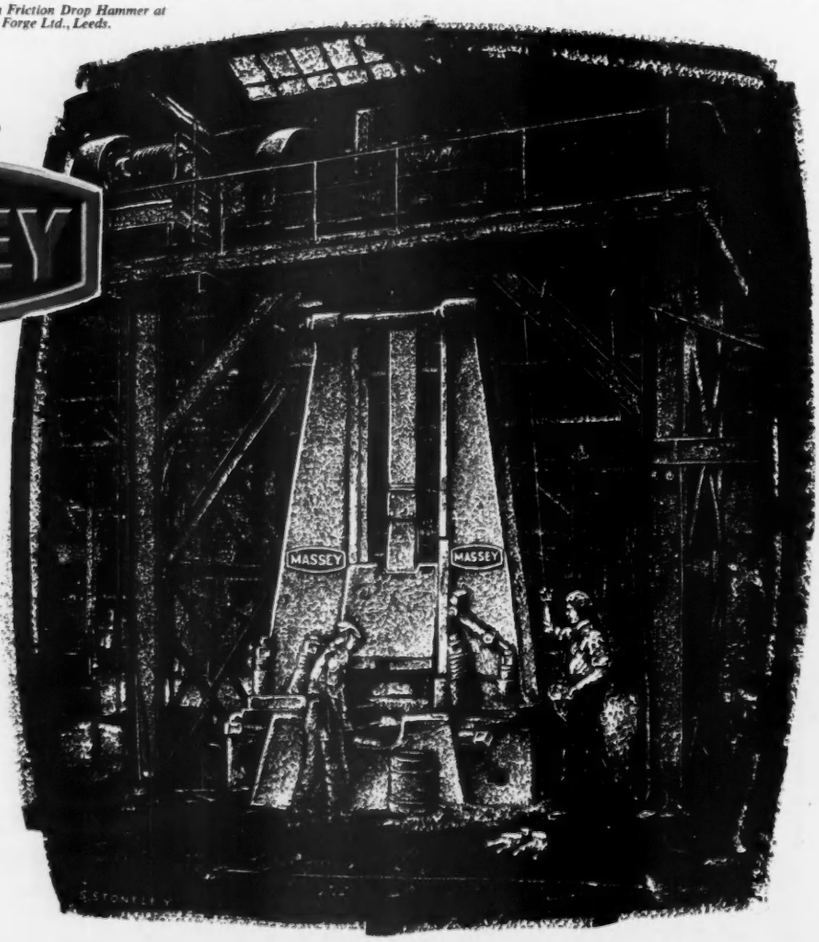

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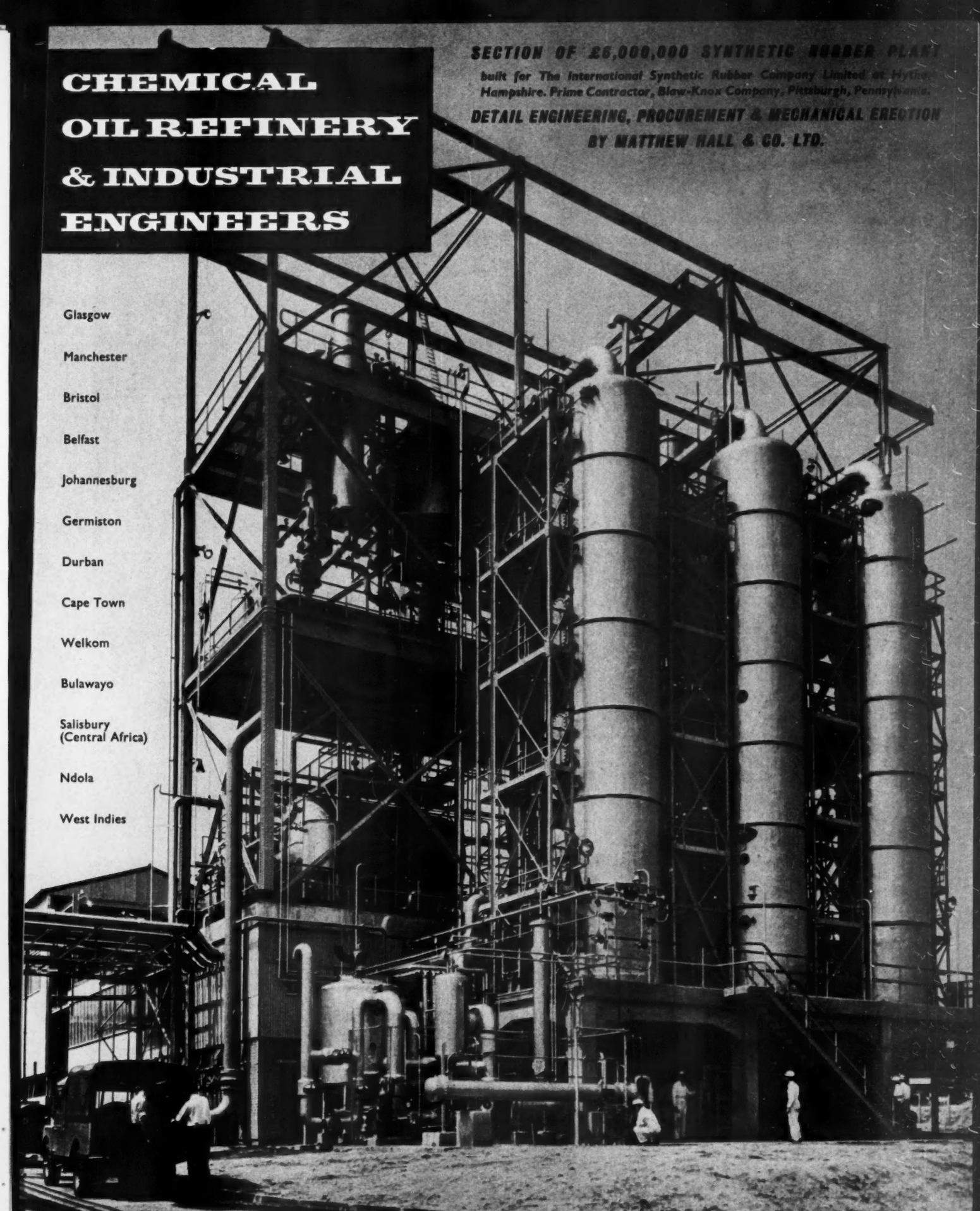

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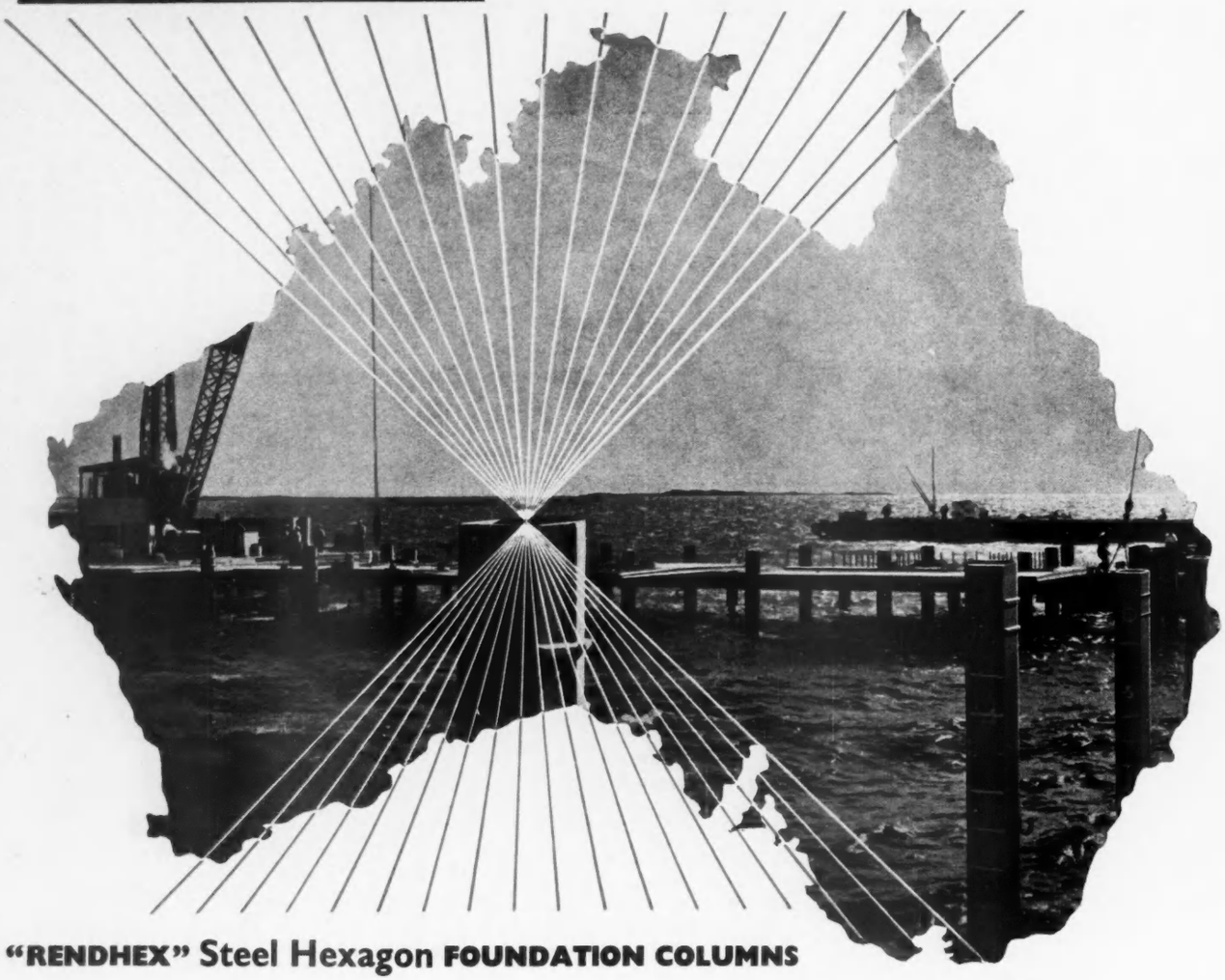

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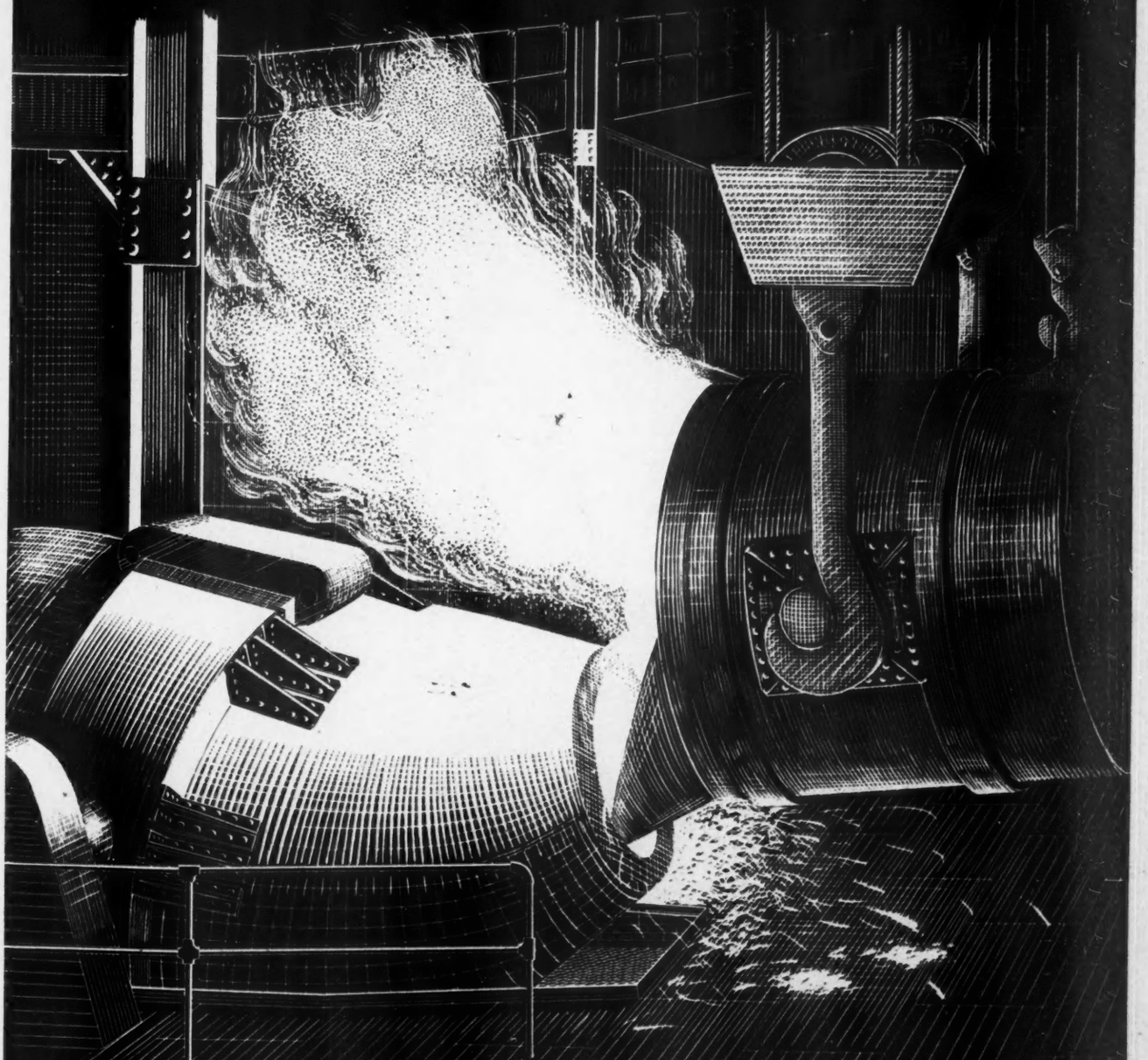

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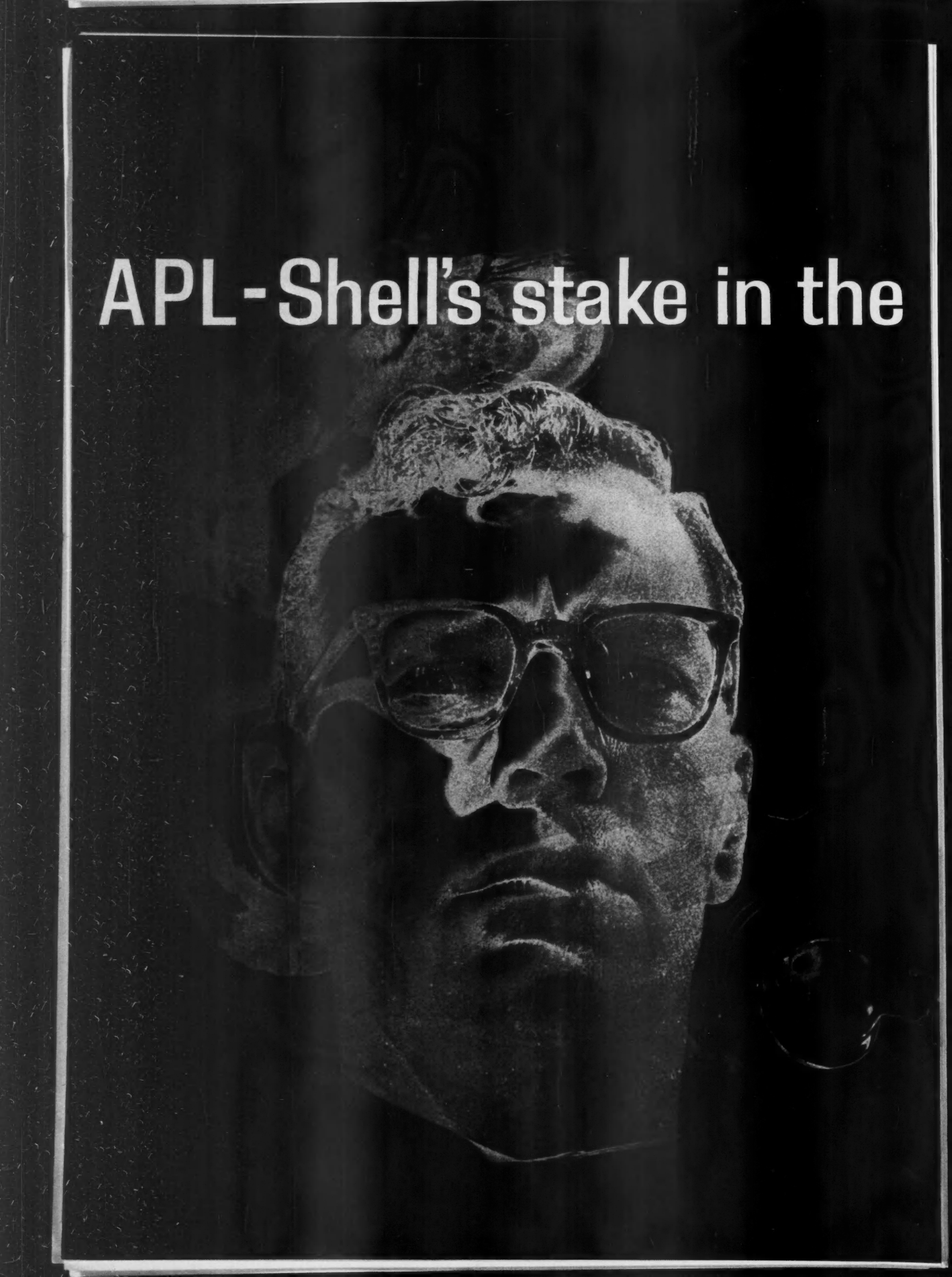

first nuclear decade

To a world hungry for energy, nuclear power brings rich promise. With it, inescapably, come complex new problems which can be mastered only by imaginative thinking.

Conventional lubricants, for instance, are useless when exposed to radiation. They break down, thicken and form harsh solids. Yet the lubricants needed for mechanisms close to the reactor may have to withstand radiation 4 million times stronger than would kill a man. Some of them have to take such punishment continuously for two years or more, for the complicated mechanisms they lubricate cannot be serviced without closing down the reactor altogether – a costly business with plant involving a capital outlay of some £50,000,000.

In 1953, when it was realised that radiation-resistant lubricants were essential, Shell decided to start an extended programme of research. Special groups were set up at Shell's Thornton Research Centre, a generous budget allocated, and their own Cobalt 60 source of radiation installed. Repeated tests took place there and under actual reactor radiation at the United Kingdom Atomic Energy Research Establishment at Harwell.

In 1957, after four years of work, the Shell group introduced the world's first range of Atomic Power Lubricants under the brand name of Shell APL – Shell's stake in the first nuclear decade.

Today, Shell APL is still the only range of proved radiation-resistant lubricants on the market. Oils and greases from this range, as well as other Shell Industrial Lubricants, are in daily use at many nuclear establishments in the United Kingdom and elsewhere – in lubricating control-rod mechanisms, manipulators, electric motors, blower fans and steam turbines. They have also been chosen for the new British atomic power station under construction at Bradwell in Essex.

Here is Shell leadership in lubrication in action – anticipating a need, undertaking fundamental research, and finally developing the products to solve a problem of world-wide importance.

The Research Story

In the hundreds of complex hydrocarbons examined, very different reactions to radiation were observed according to the configuration of the atoms in the molecules. Highly complex structures of an entirely different nature from the original material were formed. Following extensive experiments, the Shell APL range of lubricants was developed and proved. Included are such oils as Shell APL 729, mainly for use in blowers. This oil now has a performance equal to a good quality modern turbine oil. Shell APL 700 series greases have been tested in bearings operated within the BEPO reactor and subjected to CO_2 gas under pressure at 150°C. After receiving a total dosage of 2.7×10^{18} thermal neutrons plus associated radiation, the grease and bearings were found to be still in good condition.

Other lines of research include the latest developments in the use of radio-active isotopes in the measurement of wear. Recent results have been published in a paper presented at the 1958 Geneva Conference, a further example of the work continually being undertaken by the Shell group to assist industry.

SHELL

ATOMIC POWER LUBRICANTS

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Today, five years later, the range of application for SCW Cor-Ten continues to grow as more designers and more users discover new ways in which they can take advantage of its outstanding properties.

Photograph by courtesy of Caterpillar Tractor Company Ltd.

Wherever higher strength or greater resistance to atmospheric corrosion offer economic advantages, SCW Cor-Ten *has been used. Where corrosion and abrasion are both present (as in the case above)* SCW Cor-Ten's *outstanding advantages are particularly effective.*

COR-TEN IS TOUGHER

- Weight for weight, the yield strength of SCW Cor-Ten is 50% higher than ordinary mild steel
  alternatively
  Strength for strength, a saving of $\frac{1}{3}$ of the weight is possible
- 4-6 times more resistant to atmospheric corrosion
- Highly resistant to abrasion and fatigue

COR-TEN SAVES MONEY

- Initial costs are spread over a longer service life
- Maintenance costs are reduced
- Operating costs are lowered—in transport applications payloads are bigger because of reduction in tare weight

Please write to us at the address below for further information or for technical assistance in the application of SCW Cor-Ten *to your products*

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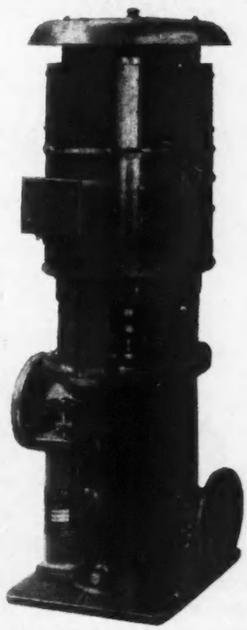

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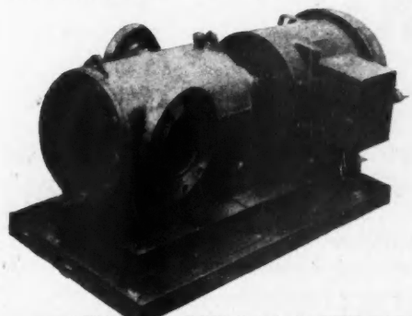

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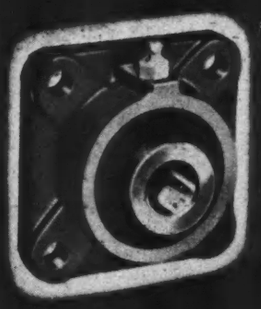

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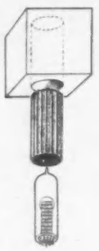

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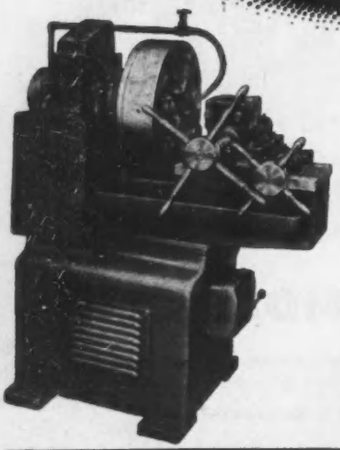

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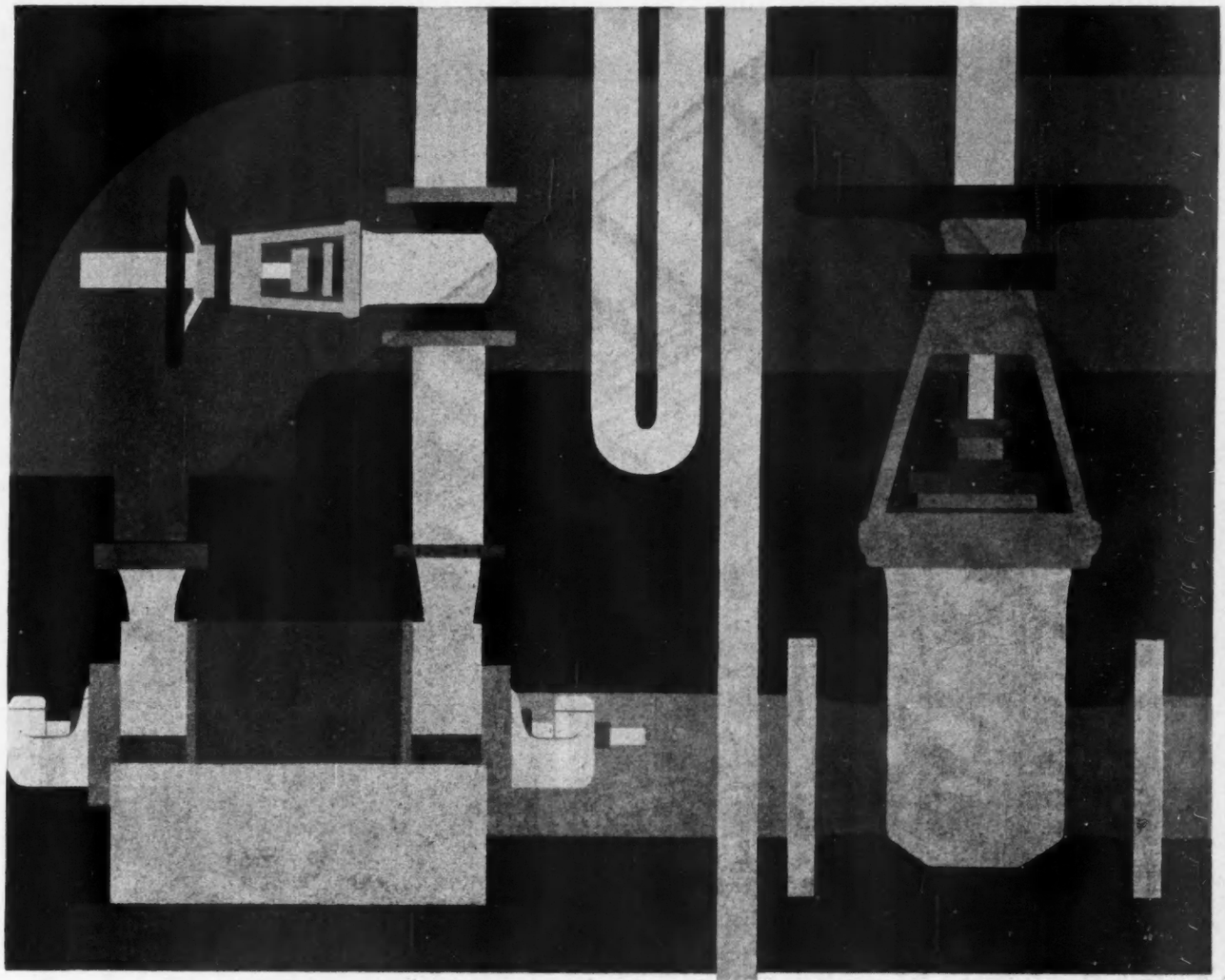

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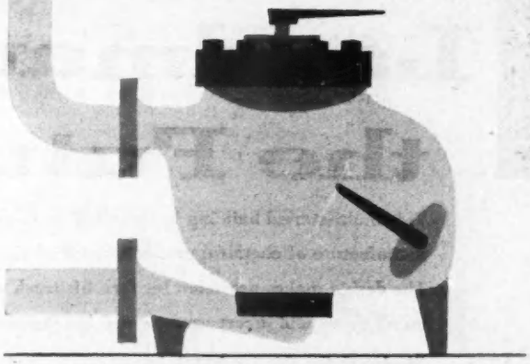

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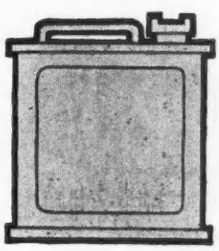

From a can of

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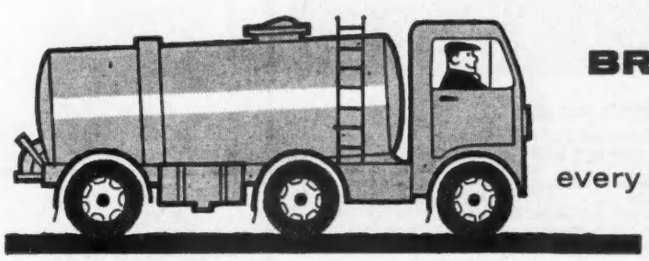
to a tanker of

TAR



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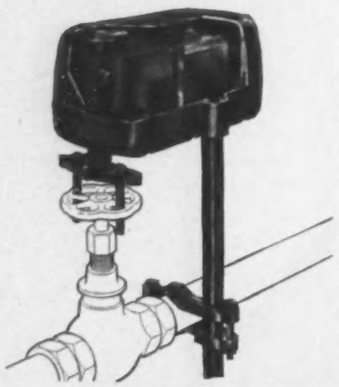

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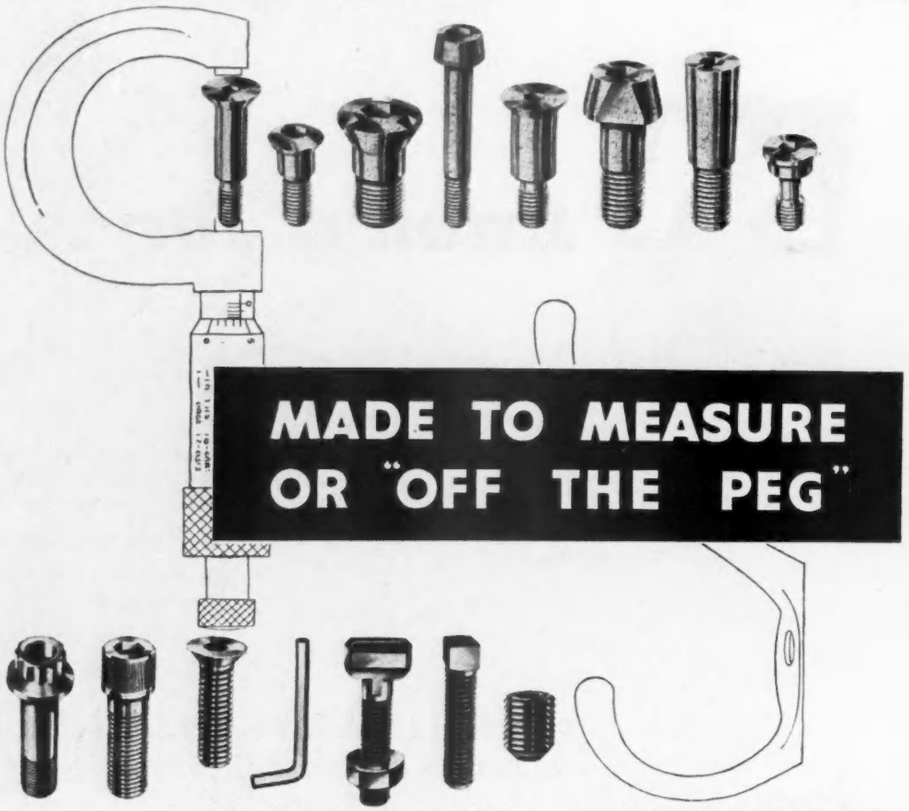

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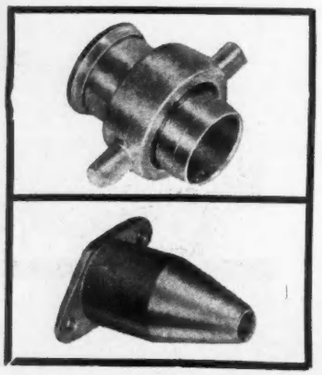

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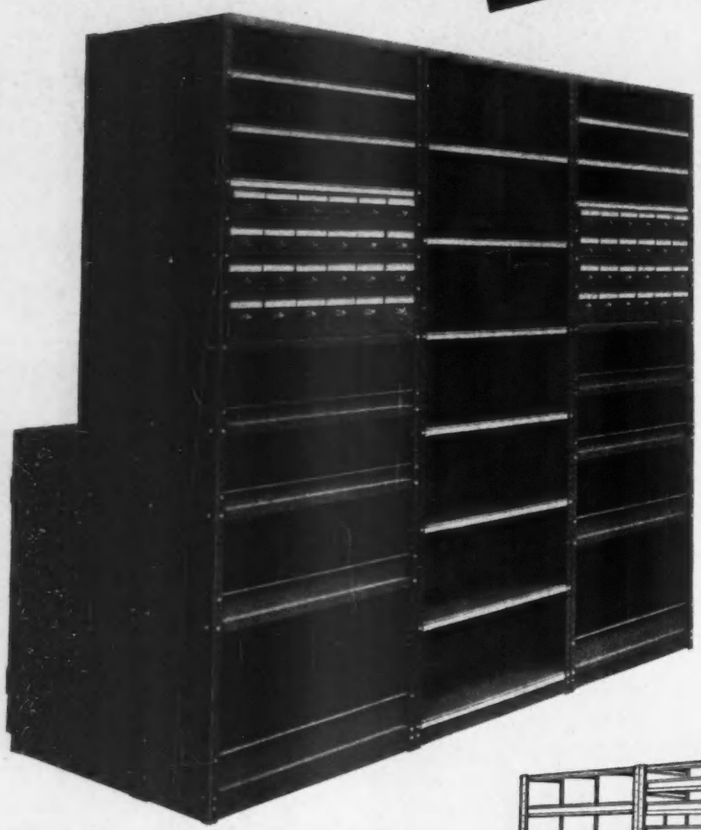

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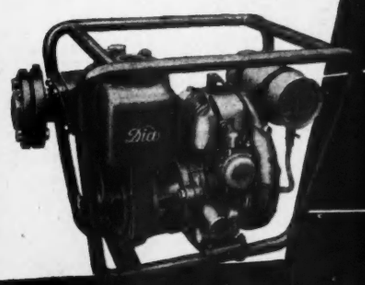

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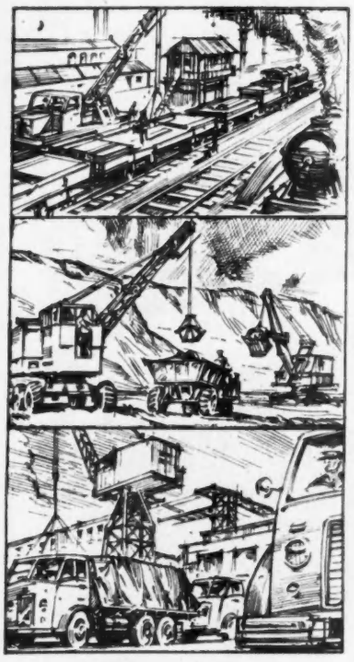

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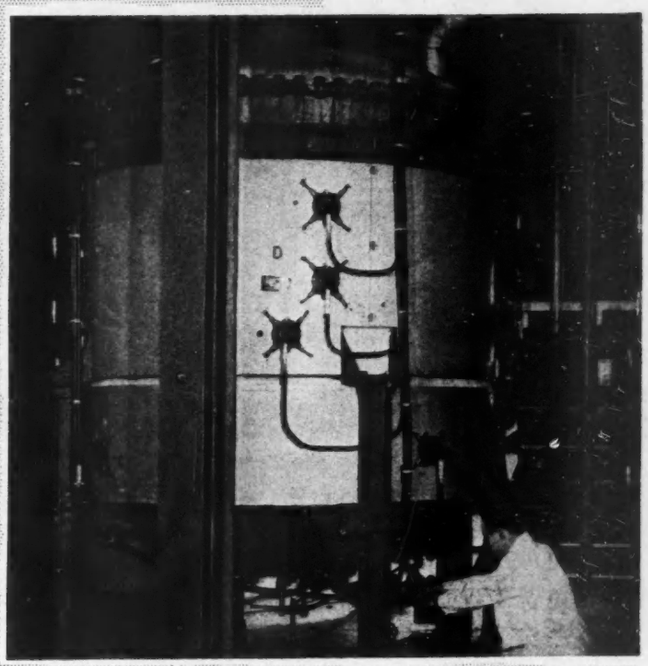

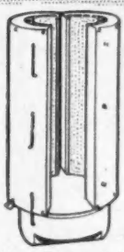

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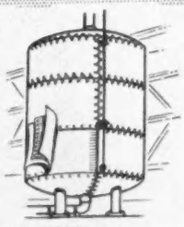

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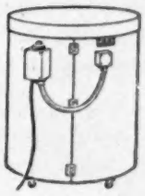

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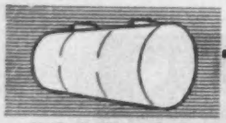
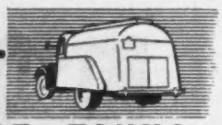

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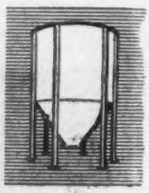

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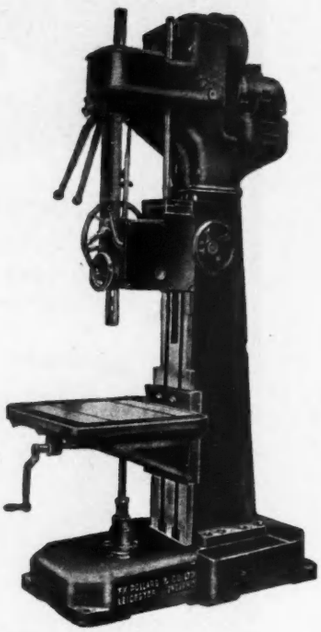

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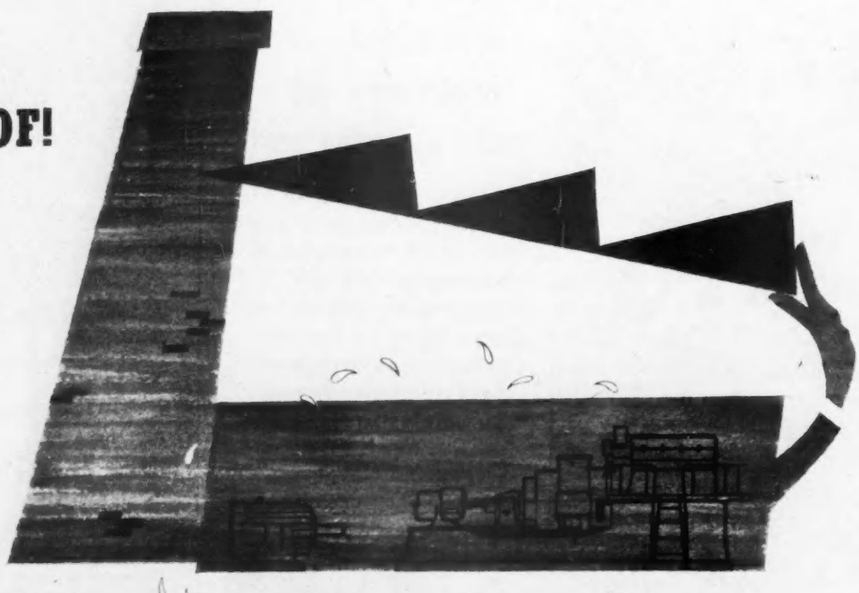

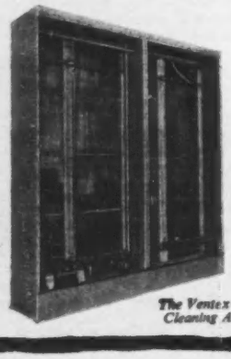

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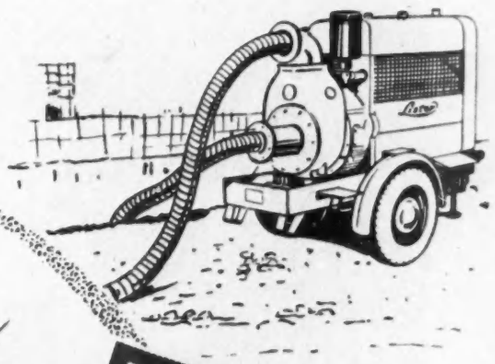

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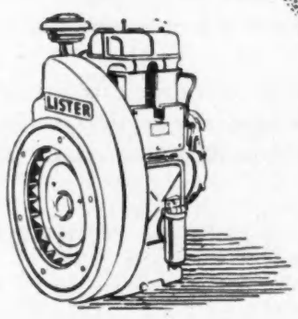

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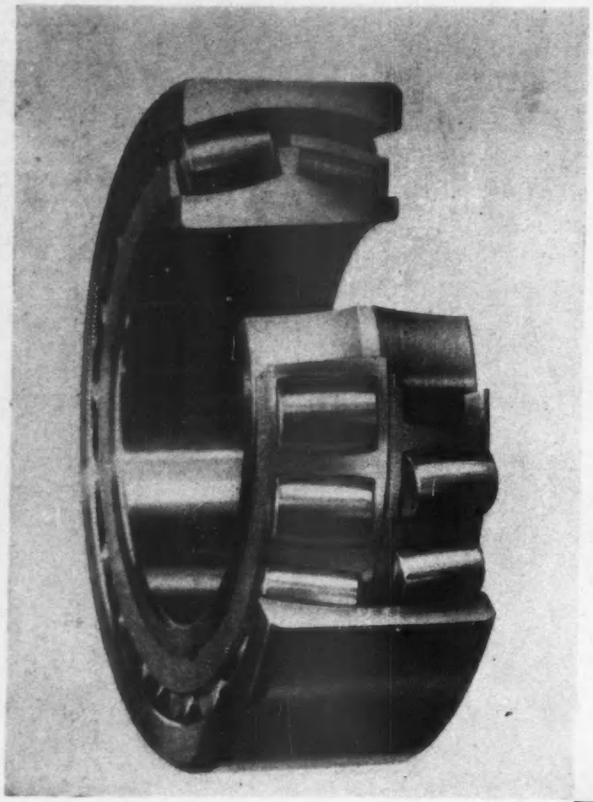

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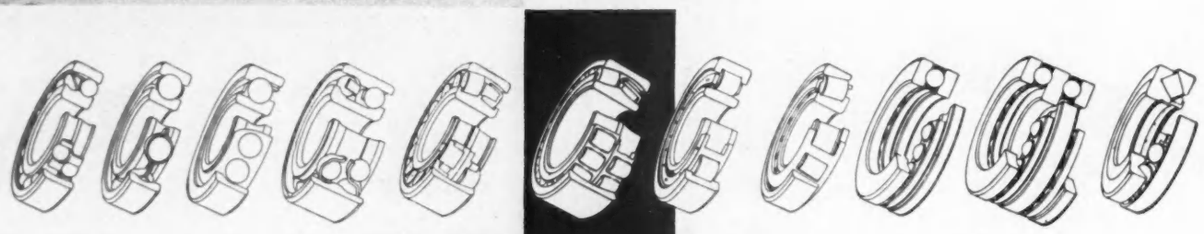

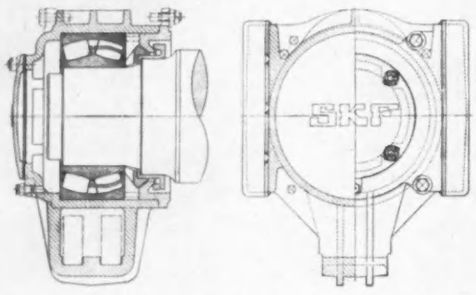

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THE ENGINEER

No. 5384 APRIL 3, 1959 VOL. 207

NUCLEAR POWER PROSPECTS

An interesting survey of the present stage of development of nuclear energy throughout the world and an assessment of the prospects for British exports of nuclear reactors are given in a recent planning broadsheet (Vol. 25, No. 431) published by Political and Economic Planning. Being a non-technical review, unencumbered by tables and footnotes, it is thoroughly readable, but, since none of its sources of information are quoted, the reader who is not prepared to do a great deal of research must swallow the facts without being able to scrutinise the statistics upon which they are based. However, as a broad survey of the whole field the report deserves study.

The first point made is that power reactors of to-day are inherently large and costly units and that they can generate electricity economically only when they are worked continuously to make the best of the high capital charges and the comparatively low fuel costs. In practice these conditions can only be realised by feeding the output into an interconnected supply system. Therefore it is in the more highly industrialised countries rather than underdeveloped lands that nuclear power is likely to compete with power derived from fossil fuels. In the U.S.A., where fossil fuels are cheap and plentiful, nuclear power stations are unlikely to be economically competitive for some time to come. In Europe, on the other hand, nuclear power is expected to be fully competitive within the next ten years for base load stations. Great Britain, as is well known, offers the best prospects : with the high cost of coal, including its transport, nuclear power is likely to " break even " on a cost basis when Hinkley Point comes into operation within the next three years. Europe's need for nuclear power depends largely upon the availability of coal, oil and water power. France, for example, expects that nuclear power will have to provide 5 per cent of her electricity requirements by 1965 and 30 per cent by 1975. Germany's needs are less urgent; but despite her reserves of hard and brown coal she may, if industrial expansion continues at the present rate, have to face a deficit of 45,000,000 tons coal equivalent by 1965. In Belgium and Luxembourg coal is the main source of energy and a gap of 17,000,000 tons coal equivalent between supply and demand is in prospect by 1965. Holland expects to be able to supply only 45 per cent of her energy needs by 1965 and 33⅓ per cent by 1975. Denmark, with few natural sources of energy, imports the bulk of her fuel and is certainly interested in nuclear power, as is Finland. In other European countries, including Norway, Sweden, Austria and Switzerland, the concern is rather more remote. Spain has deposits of uranium and plans to have 1000MW of nuclear power by 1972 and 2200MW by 1977. In the East (excluding Russia), Japan, with a programme for 7000MW of nuclear power by 1975, India and Pakistan are probably the best prospects. In Latin America the Argentine and Brazil may need between them 5000MW of nuclear power by1980.

These are some of the countries that, according to the P.E.P. broadsheet, will need nuclear power in the next ten years or so. With the exception of France, most of them will, at least initially, offer a market to any potential exporter. At present the only countries with the necessary knowledge and experience to export nuclear reactors and fuels, and provide the necessary service are Great Britain, the U.S.A. and the U.S.S.R., but Soviet aid is confined to satellite countries. The U.S.A. is a formidable competitor because lack of urgency for nuclear power at home has left the industry free to take a long view and experiment with various designs of reactor—an advantage which may be decisive in markets seeking a small and flexible reactor. Great Britain, on the other hand, because of the urgent internal demand, is at present mainly committed to the graphite-moderated, gas-cooled reactor. However, it has the advantage of being the best-tried and proved reactor. Moreover, in its more sophisticated forms—the advanced gas-cooled reactor and the high-temperature, gas-cooled reactor—it should hold its own against its rivals for land power stations for the next fifteen years at least. But, to convince potential customers, the demonstrated qualities of the Calder Hall reactors should be backed up by what P.E.P. calls " steady and impressive publicity," to match the publicity project known as " US atom," in which thirty American firms are collaborating. Finally, the prospects of British exports of nuclear reactors depends not only on the " competitive ability " of British firms, but also on the political agreements the Government is able to make.

MORE TALK ABOUT ROADS

The road programme was debated in the House of Commons shortly before Easter, when the House was asked to approve supplementary estimates. It is interesting to peruse *Hansard's* report of the debate, and observe how the current controversies about roads have been selected and presented by the various speakers to support one or other of the party lines. For instance, the Opposition speakers generally claimed that the road programme was inadequate and out of scale with the needs ; Government supporters, on the other hand, pointed out that the last Labour Government spent, on average, only £3,000,000 annually on new road construction, throughout its years of office. And so the arguments went on. It would be, we think, a fair overall summary to say that the arguments put in the debate were ill-disciplined and loose ; they, nevertheless, showed some improvement—we speak from a strictly logical and engineering standpoint—over similar debates of a few years ago. Members are now aware, if dimly, that the Institution of Civil Engineers held a highway conference just over a year ago, and that subjects such as traffic engineering are with us.

Party-politics apart, some of the general impressions from the debate are worth noting. There was still great reluctance to accept that urban motorways are necessary, especially in London. Very high cost and extensive disruption of amenities were obviously feared. There was also much concern in the debate about road accidents, and one member asserted that, since 10 per cent of accidents were due to a mechanical defect, implementation of the 1956 Act for testing

road vehicles would save 600 lives a year ; we wish we could agree with him! The Preston by-pass failure has now become almost a music hall " chestnut." It was tossed around here and there during the debate. Strangely enough, no one asked for a final technical appraisal of the failure. The official Government statement (published in THE ENGINEER of February 6 last) was only a first appraisal, and it was stated that " final conclusions cannot be drawn until there has been a period of continuous thaw." Those final conclusions would appear to be quite closely guarded so perhaps the " thaw " referred to was a political one ! The Minister quoted an argument that the failure was " nothing more serious than a slip in a railway cutting." That may be so ; slips in railway cuttings are fairly common. But the point is that they are invariably cuttings constructed fifty or a hundred years ago. A cutting built to-day, with all the techniques of soil mechanics behind it, should never slip !

But the most significant point discussed in the debate was that of the size of the present road programme, for on this hinges the adequacy and effectiveness of the road system of this country. The figures for capital expenditure may perhaps be quoted, as given by the Minister, although they are not new. Major improvements and new construction over the past four years averaged £12,000,000 ; this year nearly £47,000,000 will be spent ; next year £55,000,000 ; the year after, £65,000,000, and thereafter not less than £60,000,000 per year. For total annual road expenditure, to this £60,000,000 must be added £33,000,000 of Government money for maintenance and minor improvements, and £50,000,000 of local government contributions, a total of £143 million a year. In summing-up the debate, Mr. Nugent, the Joint Parliamentary Secretary of the Ministry of Transport and Civil Aviation, referred to the sixteen-fold increase in new construction in five years, and to the physical and professional resources of the nation. It was the biggest road programme that this country had ever undertaken, he said, and he referred to the annual estimates as " very big figures." " I am certain that the programme could not have gone any faster," he asserted, and " I am quite sure it has been set at the right level to ensure success." We think that the assessment of the professional and technical resources of the civil engineering industry implied by Mr. Nugent in his remarks, did less than justice to an industry which is vigorous in outlook and flexible in meeting the varied demands made on it. In the same issue of *Hansard*, for instance, it is stated that over the past five years, building and civil engineering work for the Air Ministry has cost £208 million ! Surely there is no need to press the comparison further, or to make other similar comparisons ? The obvious conclusion is that a far greater rate of road construction could be comfortably supported by the civil engineering industry.

RAILWAY ELECTRIFICATION IN EAST ANGLIA

Holiday motorists turning seawards over the level crossing at Frinton have seen a notice warning of the presence of a high-voltage cable overhead. The whole of the railway from Colchester to the coastal termini at Clacton and Walton is now hedged by pylons carrying the contact wire of the British Railways 25kV, 50 c/s, a.c. electrification in this corner of Essex. To the observer mindful of the frequent allusions which have been made to the lightness and cheapness of the high-voltage a.c. system, the installations may not appear to have quite the gossamer quality he had come to expect, but there can be no overlooking the contrast with the overhead structures for the 1500V d.c. electrification between Liverpool Street and Shenfield, said sometimes to be called the " copper tunnel."

The Colchester–Clacton–Walton project, shortly to be inaugurated, has gone forward without the disturbance of public services which has made " modernisation " a baleful word in some areas. Engineers faced with the problems of electrification in urban districts may justifiably feel that their colleagues in East Anglia have enjoyed unfair advantages in the local topography, where many crossings of road and rail are on the level and the whole of the wide East Anglian sky is open for the erection of structures and catenaries. This must not detract from the significance of the Colchester–Clacton–Walton electrification, which will be the first on British Railways to convey public traffic in trains built for the 25kV a.c. system. The Lancaster–Morecambe–Heysham lines have historical priority, and have been the proving ground for germanium and silicon traction rectifiers, but their rolling stock has consisted of earlier electric vehicles converted for the 50 c/s a.c. system, and the operating voltage has been 6·6kV. On the East Anglian branches, on the other hand, rolling stock and locomotives destined for later and larger projects, such as the Fenchurch Street–Southend and Liverpool Street–Bishops Stortford schemes, will operate in revenue-earning service. At Colchester the sight of the catenary suspended at one side of portal structures spanning the branch and main lines recalls that the Clacton–Walton lines will be only temporarily an island of electrification, since eventually the Liverpool Street–Ipswich route itself will be electrified at 25kV, 50 c/s. Here, too, where the branch passes under the Colchester by-pass road, a glimpse of protective wire netting at an overbridge raises an interesting question. On the Southern Region electrified lines unpaid investigators have discovered the dramatic effects produced by cocoa tins and the like skilfully aimed at the 660V live rail. In Yorkshire a railway engineer has told us sadly of old bicycle frames and wire mattresses tipped over bridge parapets on to the 1500V conductor of the Manchester–Sheffield–Wath electrification. What massive ironmongery will be considered worthy of immolation on a contact wire carrying 25,000V and some of the hopes of British Railways for a prosperous future ?

GAS AND ELECTRICITY IN COMPETITION

The report of the Committee on Co-operation between Area and Scottish Electricity and Gas Boards printed as a White Paper and published shortly before Easter gives no comfort to those who want to find a stick with which to beat two nationalised industries or who have an itch to organise other people better than they can organise themselves. For the Committee found that, with possible exceptions in certain isolated areas, no advantages either to the consumer or the Boards would follow through arranging for a single inspector to read gas and electricity meters simultaneously and to deal with prepayment meters ; that there would be no advantage to anyone in joint billing arrangements ; that there is no case generally for the sharing by Boards of service centres and show rooms ; that the Boards do not appear to spend too much on advertising ; and that though there should be good liaison between authorities requiring upon occasion to dig up streets to lay, repair, or renew mains, it is not always possible to avoid multiple disturbances of streets. It is to be noted, however, about all these negatives, that it was made clear to the Committee before it started work

that it was not to be concerned with the general policy of the Electricity and Gas Boards or with competition between them. Possibly therefore some of the Committee's conclusions might have been different if it had been able to contemplate co-operation rather than competition. But we rather doubt it. It turns out, for instance, that it is rather more than less convenient for the public to be visited by two inspectors than one, and to have to pay two relatively small bills instead of one large one ; and that, in fact, it is by no means certain that it would be any cheaper for inspectors to read both meters and for a single bill to be sent in to the consumer. If there were co-operation between the two industries no doubt separate show rooms would disappear. But would sales staff maintain the same enthusiasm if the stimulus of competition were removed ? Certainly, the industries would still have to advertise, as it is through publicity of one kind or another that they are able to bring improved appliances to the notice of the public, to show how well adapted gas and electricity are for certain purposes, and to tell the public about activities designed to improve the service or its efficiency.

But the Report is not, as might appear from this account, quite as negative as a Russian diplomat negotiating with the West. The Committee had some, even if only minor, positive recommendations to make. Attention is drawn to the advantages of billing by estimated readings, thereby reducing the number of calls from meter readers, and Boards are encouraged to experiment with various meter reading and billing arrangements. It is suggested that there is scope for applying work study to the task of meter reading and collection from prepayment meters. It is thought that a rather wider use of mobile show rooms could be made in rural areas to the advantage of consumers. Further the Committee believes there is scope for improving and extending the informal working arrangements between the Boards of the two industries. But these positive recommendations detract little from the generally negative character of the Report. A cold douche has been applied to those who expected to learn that the industries were obstinately unco-operative and inefficient.

OVERLAPPING OF BRITISH STANDARDS

The number of standards produced by the British Standards Institution grows apace. Perhaps it is growing too fast. For there does seem now to be a certain amount of unnecessary overlapping. The following remarks relate in particular to the standards which deal with prime movers and driven machines—oil engines, steam, gas and hydraulic turbines, pumps, electric generators, &c; but we suspect they may apply also to other fields. Some of these standards have been recently revised and some revisions are still in preparation. All are of undoubted value to manufacturers, purchasers and inspectors. Some of the documents to which we refer are described as " standards," whereas others are described as " standard test codes." The contents of the latter should presumably cover only methods of testing. For both classes of document, testing is an important part of their contents and in most cases, speed, horsepower, electric power and other quantities have to be measured during testing. This fact has led several of the technical committees responsible for drawing up the standards to the belief that their drafts should include sections describing how these various quantities should be measured. For example, the draft British Standard for gas turbines has clauses on dynamometers and speed measurement. The British Standard for steam turbine acceptance tests describes the methods of measurement of electric power. It must, of course, be agreed that where measurements are of special importance or peculiar to the machine being tested they are proper subjects for the relevant standard—speed in relation to gas turbines and water flow in the case of hydraulic turbines are cases in point. But detailed requirements for dynamometers and other testing equipment common to many types of test should surely be excluded. They would figure more appropriately in a special standard for the testing machine, or form part of a comprehensive code covering test apparatus in general. A particularly unfortunate example of overlapping is that provided by a proposal now under consideration for a standard for I.C. engine-driven generating sets. Recently revised and presumably adequate standards already exist for both engines and generators and an additional document can surely only cause confusion, particularly because it is apparently to be produced by a separate committee and one at least of the committees responsible for the component standards does not seem to have been consulted.

There appear to be three reasons which have brought about the present state of affairs. First, there is a quite natural desire on the part of any drafting committee to make its draft fully comprehensive. Secondly, there may be a lack of co-ordinating guidance from the appropriate industries committee of the B.S.I. Lastly, committees often seem tempted to prepare textbooks rather than standards with the apparent object of enabling inexperienced persons to carry out tests. Is that the real object of a standard ? It rather looks to us as though the directive to each committee needs to be given in more detail than it is at present; possibly the scope clause at the beginning of each standard should be approved by the senior committee before drafting starts. It might also be desirable to bring together in one standard all common methods of measurement applicable to works testing, as is already being done in respect of power measurement.

The Engineer—100 Years Ago (APRIL 1, 1859)

" NEW WESTMINSTER BRIDGE "

" There are few public works—excepting the immovable clock of the new House of Parliament—whose non-progress excites more widespread interest than those in connection with the new bridge at Westminster. It may be that the public, looking to the condition of the ruin over which the traffic is still continued, are keenly alive to the truth of the adage that delays are dangerous ; but, whether arising from this or other causes, the anxiety to see the new structure complete and opened is undoubted, and increasing day by day. Never was a new bridge more wanted than at Westminster, and never has such a long succession of unfortunate and almost unavoidable delays occurred to mar its progress. According to the least sanguine of calculations the Western half of the bridge should have been opened for traffic last January, yet April beholds the ironwork of the new arches still unfixed.

" Great part of this long delay, however, arose out of the first contract with Mr. Mare, to which we need not further allude, save to add that in this respect the loss of time was totally unavoidable. The delay which has since then taken place may be in part assigned to the dilatoriness of the late Board of Works and the mal-arrangement of the contracts into which they entered for the supply of materials, especially with regard to the ironwork. . . . The materials of which the new bridge will be constructed are 45,700 cubic feet of timber used in the bearing piles, 1,600 tons of cast iron, and 70 tons of wrought iron employed in the foundation of the bridge. In the superstructure there will be 2,600 tons of cast iron and 1,500 tons of wrought iron. The piers and abutments of the bridge swallow up 165,000 cubic feet of granite and other stone, in addition to 21,000 cubic yards of brickwork in Portland cement, and 30,000 yards of concrete also in Portland cement."

Air Engines

By T. FINKELSTEIN, Ph.D., D.I.C., B.Sc., A.M.I.Mech.E.*

No. II—(*Continued from page 497, March 27*)

In these articles a survey of the development of air engines is given, starting with the primitive "furnace gas engine," built at the beginning of the nineteenth century, and leading up to the modern single-stage Philips' air liquefiers. The different types of air engines are classified into three groups: open cycle internal combustion, open cycle external combustion and closed cycle engines, invented respectively by Cayley in 1807, Ericsson in 1840, and Stirling in 1816. The principle of operation for these is explained and typical examples of each are given. Engines ranging from a small toy motor to a monstrosity with four 14ft diameter cylinders, running at 9 r.p.m., are described. To the writer's knowledge this is the first time that a comprehensive set of illustrations and descriptions of air engines has been assembled—in fact, a picture of Stirling's original engine of 1816 has previously appeared in print on only one occasion. Recent new developments are dealt with and some interesting proposals for future applications of these basic scientific principles are made.

Stirling Engines

IN open cycle engines mechanical work is performed by a quantity of working fluid which is made to undergo successively certain operations, such as induction, compression, heating, expansion and exhaust. On the other hand, in closed cycle engines these phases merge into each other, and while part of the working fluid may be heated in one part of the engine, in another part it may simultaneously be cooled. Thus the process is rather more difficult to understand. The invention of the closed cycle external combustion engine by Stirling in 1816 is therefore probably one of the most amazing inventions that has ever been made. It was so much in advance of scientific knowledge at the time that at least thirty years passed before anyone was in a position to understand what made the engine work at all. Nearly 100 years later engines were still "invented," which, due to lack of understanding of the fundamental principles, missed such essential features as the provision of a regenerator, or compact cylinder arrangement, whose importance Stirling must have realised intuitively.

This invention was made by the Rev. Robert Stirling, D.D., of Cloag, Methvin, Perthshire, when he was twenty-six years of age and had just been ordained to his first parish. Robert Stirling's family produced a number of prominent engineers for several generations, from his grandfather, Michael Stirling, the inventor of the first rotary thrashing machine in 1756, to his four sons, all of whom became well known mainly as railway builders in places as far apart as Honolulu, Chile and Scotland.

The original patent, No. 4081 of 1816, had the very obscure title "Improvements for Diminishing the Consumption of Fuel, and in particular an Engine capable of being Applied to the Moving of Machinery on a Principle Entirely New." In it Stirling not only described the construction and use of a regenerator for the first time in history, but also seems to have foreseen its principal applications, such as for glass furnaces or iron smelting. In addition to this, it also included a description of the first closed cycle hot air engine, as shown in Fig. 6, reproduced from the original patent specifications. In this illustration only minor alterations which were called for by incorrect perspective in the original, have been made. It should be noted that this engine was considered by Stirling to be a logical development based on the regenerator, a fact sadly neglected by later innovators.

Even to-day, the working principle of this original Stirling engine, as well as that of many later engines based on this prototype, is rather difficult to understand. Special diagrams explaining the working principle are therefore shown here in Fig. 8. At the top of this illustration an idealised "Stirling cycle" is drawn on a pressure-volume, and on a temperature-entropy diagram respectively, with terminal phase points marked *a*, *b*, *c* and *d* respectively. Below this a circular phase diagram is shown, with each of the four quadrants corresponding to one of the main phases. The enclosed working fluid is represented as a rectangle whose area corresponds to the variable volume, with the position of the regenerator indicated by a dotted line. In this diagram the temperature of the working fluid is indicated by cross-hatching that portion which is at the higher value. The sequence of events is clockwise, as indicated by arrows. At phase point *a* the volume is a maximum, but the temperature is low. Between *a* and *b* this temperature remains constant, while the volume decreases to a lower value up to point *b*. Between *b* and *c* the volume is kept constant and the regenerator is passed through the working fluid, or conversely, the working fluid through the regenerator. In either case the effect is to raise the temperature throughout the bulk of the working fluid to the higher value. The remaining two phases *c*–*d* and *d*–*a* correspond again to phases *a*–*b* and *b*–*c* respectively. Thus, in principle a Stirling engine is a mechanism whereby the total volume of a quantity of gas is periodically altered by means of one or more pistons, while a regenerator is used during successive

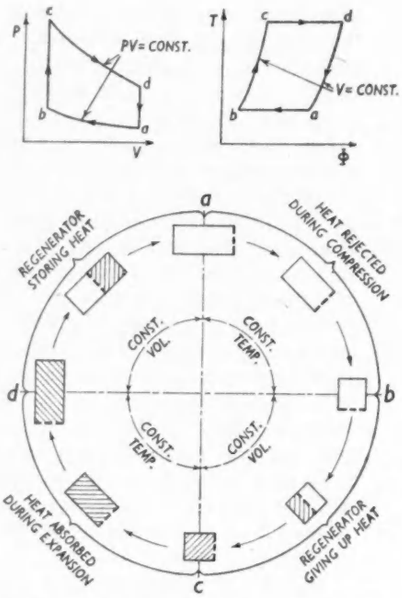

Fig. 8—The principle of operation for the Stirling cycle is shown here with reference to a pressure-volume and a temperature-entropy diagram as well as a circular phase chart

* Section Head, Mechanical Engineering Laboratories, The English Electric Company, Ltd., Whetstone.

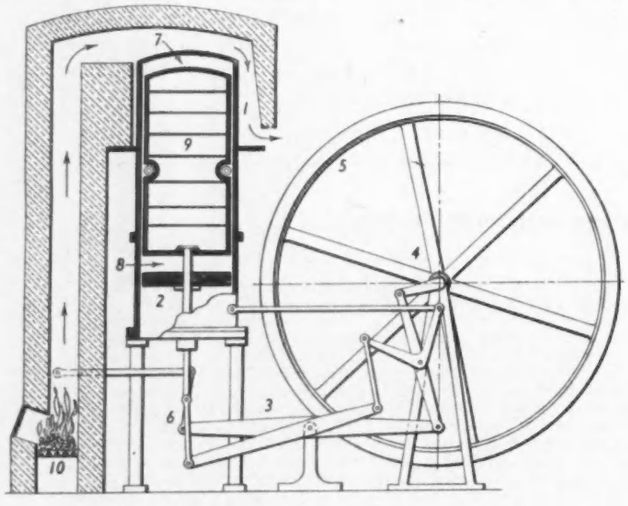

Fig. 6—Reproduction of drawing showing the first Stirling engine from the original patent specifications of 1816. Such an engine was used in 1818 for pumping water from a quarry

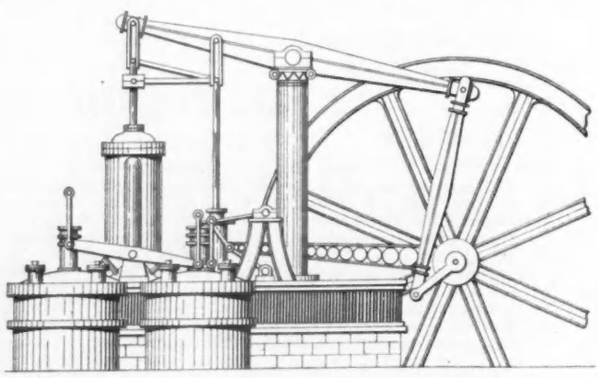

Fig. 7—Copy of an old engraving showing a beam engine working as a two-cycle Stirling engine, dating back to about 1827

transfers of the working fluid between two spaces at different temperatures.

The operation of the Stirling engine shown in Fig. 6 can now be explained with reference to this cycle diagram. The working fluid was confined in a vertical cylinder 1 about 10ft high. The volume of this working fluid was varied in accordance with the diagrams of Fig. 8 by means of a piston 2, about 2ft in diameter. This piston was driven by a mechanism corresponding to a layout usual for steam engines of that time—that is, by means of a rocking beam 3 worked by the crankshaft 4, with the large flywheel 5, about 8ft in diameter, mounted on it. As accurate sliding surfaces for a crosshead could not be produced with the materials and workmanship available in 1816, without " untowardly frictions " in the words of the period, the piston is driven via a link motion 6, corresponding to a Watt's straight line mechanism. The only novel feature of this mechanism is that it was turned upside down in order to keep the operating temperature of the piston at a low value. The working fluid enclosed in the cylinder 1 was divided by the displacer 9 into two parts. These are the hot space and the cold space, marked 7 and 8 respectively. The upper space 7 is kept hot by products of combustion from a fire in grate 10. These gases are led up a duct and surround the upper part of the cylinder before being passed up the smoke stack. While this jacketing by hot flue gases kept the upper end of the cylinder hot, the lower end was kept cool.

An arrangement for water cooling the lower space 8 is mentioned in the specifications, but is not shown in the illustration. This is because an engine of this type probably works better without this water cooling, a rather paradoxical fact that can be attributed to excessive heat conduction along the cylinder and which was confirmed by the writer in experiments with a similar engine. The displacer 9 had the regenerator mounted in a narrow annular space on its cylindrical surface and was reciprocated through the mass of the working fluid in accordance with the principle shown in Fig. 8. The link motion actuating it consisted of a central push rod passing through piston 2, and an auxiliary beam worked out of phase to the main beam by a cranked lever mounted on the connecting rod. There was probably a slider on the parallel motion, though the illustration is not very clear on this point. The displacer was hollow, made of thin riveted iron sheets, and had a diameter rather smaller than the cylinder. It was fitted with small wheels to keep it central, which left an annular space about ½in thick for the regenerator. This regenerator was made of thin wire, which apparently was wound on the displacer body in a spiral fashion with successive layers criss-crossing at right angles until the annular space was nearly filled. The engine was also fitted with a governor which opened a cock near the lower part of the cold space to atmosphere whenever the engine was racing on light load.

Although figures for power output of engines dating back to the early nineteenth century are hardly reliable, by all accounts the engine shown in Fig. 6 seems to have produced about 2 h.p. An early model was installed in 1818 at an Ayrshire quarry for pumping water and worked for about two years until the cylinder cover became overheated. It is quite likely that this may have been the first practical application of all air engines.[43]

A rather romantic story is connected with these patent specifications, as recounted in references 5, 40, 41 and 42, when the specifications were reprinted in honour of the centenary of the invention. Apparently it was customary in 1816 not only to " seal " an invention but also to " enrol " it within a stipulated period, usually about six months. It was necessary to take the specifications to one of three enrolment offices in London, and an extra payment of £5 had to be made. This fee was additional to many other payments that were needed in those days for the issue of a patent, and for this the specifications were copied on to parchment and " enrolled " by stitching this new section on to the end of the preceding patent to make one long continuous roll. These ancient rolls are still stored at the Record Office, but it would appear that Stirling's specifications are not included. Five pounds must have been a lot of money in those days, and it would not be surprising if at the time Stirling was not able to afford such a large sum in addition to fees for an agent in London or his own travelling expenses, and therefore omitted " enrolment."

Thus it would appear that Stirling's original English Letters Patent had become null and void, and although the title was entered in the ancient " Docquet Book of the Great Seal," in which patents granted up to 1852 were registered, the subject matter and the drawings remained lost for the next 100 years. In a very thorough survey in 1884, made by one of the foremost authorities on heat engines in a series of lectures on caloric engines, no mention of these original specifications is made. Though the author knew that Stirling had invented the regenerator and certain types of air engines, he did not know about Stirling's original specifications of 1816 or of any engine constructed in accordance with the layout shown in Fig. 6.[13]

The way in which these documents eventually turned up is still shrouded in mystery. Apparently some papers were cleared up in some unspecified private house and, lo and behold, Stirling's original specifications were discovered and duly returned to a member of his family. Perhaps a researcher with a historical rather than a technical interest in this matter will one day shed further light on the circumstances of the mysterious disappearance and eventual recovery of these documents.

It seems that several people later tried to contest Stirling's patents for regenerators. Amongst these was Ericsson, who, as mentioned before, unsuccessfully claimed priority for a regenerator.[8] During the better known Neilson hot-blast trials in connection with iron smelting furnaces, copies of Scottish patents were produced which must have been registered independently from the English patents.[5, 42]

Further development of the original model, shown in Fig. 6, was carried out by Robert Stirling in collaboration with his brother, James Stirling, who was an engineer by profession. One early improvement which James Stirling introduced was the use of an elevated pressure level by means of a force pump. Another innovation of rather doubtful value was the construction of a " twin-engine," which had a double-acting power piston and separate displacer cylinders and which due to the loss of Stirling's original patent was later erroneously thought to be the forerunner of all closed cycle hot air engines.

One of the very rare illustrations of such an engine that has survived is reproduced in Fig. 7 from a woodcut in reference 44. The huge flywheel (16ft diameter), the ornamented beam pillar, and what corresponds to an eccentric strap and rod of old lattice form, look similar to parts of old steam engines. It is quite likely that, in fact, many parts of the transmission mechanism had been adapted from a contemporary beam engine. Experts in engineering history will note the usual combination of a Watts straight line motion for driving the link corresponding to the condenser pump rod with a pantograph mechanism connecting up with the main piston rod, an arrangement that had become conventional for most beam engines since its introduction by Watt many years earlier.

In this engine two large displacer cylinders are provided, as shown in the left foreground. Each of these must have been heated by a fire underneath, while a displacer-regenerator reciprocated inside. These displacers were provided with four guide rods and were driven through an auxiliary rocking beam, so that they moved 180 deg. out of phase with each other. From each of these large cylinders, short connecting pipes, rather picturesquely called " nosles " in contemporary descriptions, led to the main double-acting power piston. Thus this engine worked on two cycles, carried out respectively in each of the displacer cylinders in conjunction with half the power cylinder, either above or below the double-acting piston. A fourth smaller cylinder is fitted between the power cylinder and the main beam pillar, in a position usually occupied by the condenser pump in steam engines. This is an air pump which was used to compress the air from atmosphere into the two working spaces.

In the old engraving, which is reproduced without substantial changes in Fig. 7, several obvious mistakes had been made by the artist. The displacer linkage driving the small rocking beam could obviously not function as shown, but would simply lock. The suspension of the air pump rod is also incorrectly shown—in practice there would have been a joint halfway up the vertical link. A diagrammatic distorted section through this and similar later engines built by Stirling is, therefore, shown in Fig. 9, in

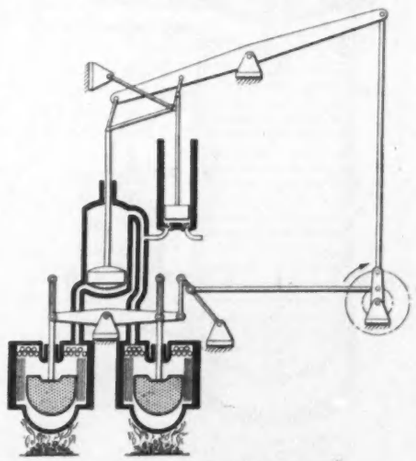

Fig. 9—Diagrammatic cross section through an early two-cycle Stirling engine showing the arrangement of the driving mechanism that was probably used (Not to scale)

which an attempt was made to reconstruct the linkage that was probably used in these engines, and in which the layout of the cylinders and the working spaces is clearly shown.

Between 1824 and 1840 several improvements and modifications were made by the Stirling brothers to their earlier designs, and further patents were registered in their joint names in 1827 and 1840 (Nos. 5456 and

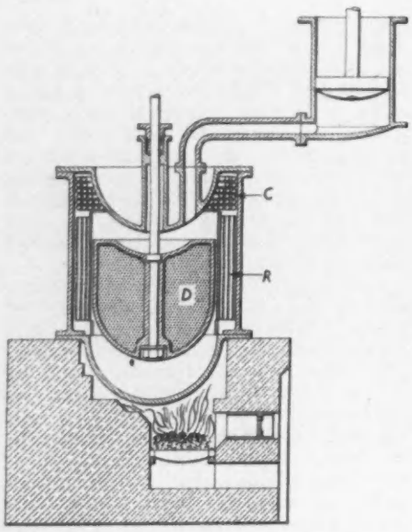

Fig. 10—Design of the displacer and power cylinders of a double-acting type of engine by Robert and James Stirling in 1827

8652). Figs. 10 and 11 have been reproduced from these later specifications. In Fig. 10 a section through the furnace, displacer cylinder assembly and power piston in an earlier improvement is shown. The regenerator *R*, which in this design was made of cylindrical metal sheets, is here transferred into an annular space surrounding the displacer *D*, so that instead of being carried through the air by the displacer, the air is pushed through this stationary regenerator. The displacer *D* was made of a hollow metal casting which was filled with brick dust. For some reason

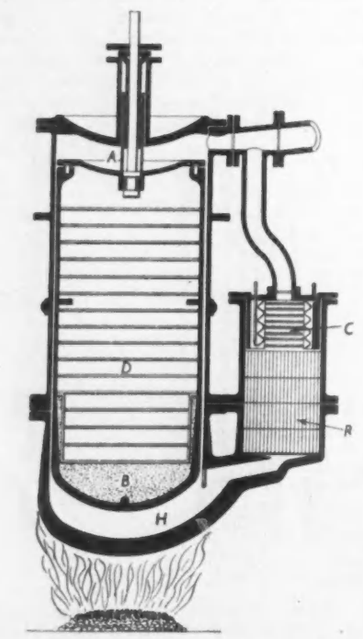

Fig. 11—Further improvements to the double-acting Stirling engine which was patented in 1840, with the regenerator and cooler in a duct outside the displacer cylinder

this was widely copied later on and some magical properties seem to have been ascribed to brick dust. Though many later hot air engines dispensed altogether with a regenerator, they still used brick dust for filling their displacers.

In experiments with a machine built in 1824, Stirling noticed that although the engine would work very well without cooling when starting up, the power tended to drop when the upper ends of the displacer cylinders became hot. This suggested the use of a separate cooler. The stationary regenerator allowed the provision of an efficient cooler *C* at entry to the cold space, made of coils of copper pipes through which cold water circulated. It is evident that with Stirling's earliest engine, shown in Fig. 6, air cooling by natural convection was quite sufficient to balance the heat input by the heat transfer from the flue gases at the upper end. With the improved models, where the cylinder bottom was exposed directly to the flames, this was no longer the case, and water cooling had to be used.

One disadvantage of these twin engines, when compared with the original single cylinder design, was that the volume of the "cushion air," or dead space, was relatively large, which diminished the compression ratio and hence the output. In this engine the total volume of clearances at the cold end was 1·2 and at the hot end 0·31 times the swept volume of the working air.[45] In a well-designed engine these ratios could well be 0·25 or less. The weight of these engines was also enormous. For a 3·7 h.p. engine, 1 ton per indicated horsepower was quoted so that the specific weight was probably more than 3 tons per brake horsepower.[20]

From experience gained with this engine, still further improvements were introduced by 1840, as shown in Fig. 11.[13, 46] With relatively short displacer cylinders in earlier engines, the upper ends still tended to become hot and in this model the whole cylinder was therefore made much longer. The regenerator *R* and the cooler *C* were transferred into a separate enclosure outside the cylinder, with three connecting ducts to the bottom of the displacer cylinder and one to the pipe leading to the power cylinder. The regenerator *R* was made of stacks of iron sheets 0·025in thick, separated by ridges with passages about 0·020in wide. To reduce longitudinal heat conduction, the regenerator was subdivided into four stacks. The cooler *C* was made of a nest of copper pipes 0·125in bore and 0·250in outer diameter, with gaps 0·050in between the tube walls. To minimise the dead volume, the space between the regenerator stacks and the cooler was filled with pieces of broken glass, which also acted as part of the regenerator matrix. The cylinder bottom *H*, which in all early hot air engines was very liable to burn out, was thickened up appreciably and an air pump (not shown in the diagram) with a delivery pressure of about 150 lb per square inch was used. Great care was taken to make this engine airtight under the high pressures used. Quoting from the specifications: ". . . . a small strip or wire of lead is inserted at all the other joints to render them airtight, and the whole is strongly bolted together, and being calculated to support 1000 lb, is proved by water pressure from within 700 lb upon the square inch. . . ."

The displacer *D* was made longer and was filled with brick dust only at the lower end *B*. Horizontal thin iron plates supported the walls, which must have resulted in a very great reduction of the heat loss transferred through the displacer from the hot space to the cold space, by the introduction of insulating layers of air. As in the previous model, care is taken that not only the power piston, but also the packing of the piston rod works in a cold portion of the engine. In this later arrangement there is an ingenious contraption to eliminate leakage of air through the gland at *A*. The piston rod is surrounded by a long, cylindrical pipe which is filled with oil. A leather collar is clamped at the upper end to form a collar round the piston rod, while the lower end permanently dips into the oil. The idea behind this early seal may have been clever, but it is easy to see now that it could hardly have withstood any pressure, even at the very low speeds used, although no records to this effect were left.

By that time the inventors had realised the harmful effect of unnecessary dead space, more so than many later engineers, as can be seen from the following further extract from the specifications:—

". . . as every portion of space within the air vessel, cylinder, plate box and passages takes in a quantity of air when the pressure is increased, and gives out a quantity when the pressure is diminished, so as to impair the impulse given to the piston, we carefully guard against all unnecessary space in the interior of the engine and in particular we make the passages as narrow as is consistent with the easy motion of the air. . . ."

One industrial application of this engine was a 45 h.p. installation in a foundry in Dundee which is shown in Fig. 12. This was an old beam engine which had been rebuilt

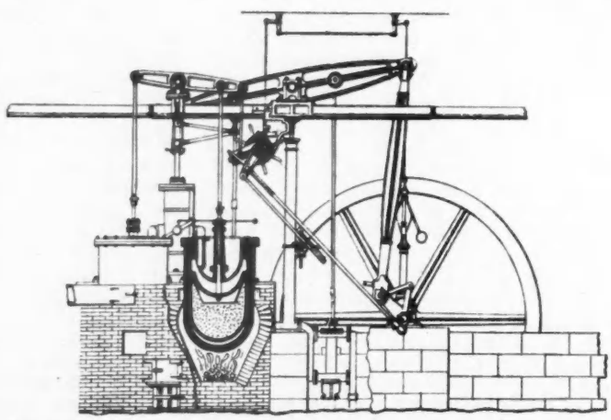

Fig. 12—Old beam engine converted in 1843 into a two-cycle Stirling engine and rated at 45 h.p. at 30 r.p.m.

to Stirling's specifications. Rated at 45 h.p., its bore and stroke was 1ft 4in and 4ft respectively, and it ran at the sedate speed of 30 r.p.m. The minimum and maximum cycle pressures were 10 and 15 atmospheres and the terminal air temperatures were 100 deg. and 600 deg. Fah respectively. With an output of 37 b.h.p., the coal consumption was claimed to be 2·7 lb per brake horsepower-hour and "sometimes" even 2·5 lb per brake horsepower-hour.[46] Most probably these figures were somewhat optimistic, as this would correspond to a specific power of about 3·3 b.h.p. per cubic foot swept volume—a figure too good to be true.

The engine was first started up in March, 1843, and seems to have run satisfactorily until a cylinder bottom burned out in December, 1845. When replaced, the second cover lasted until May, 1846, and a third until January, 1847. At that stage, the

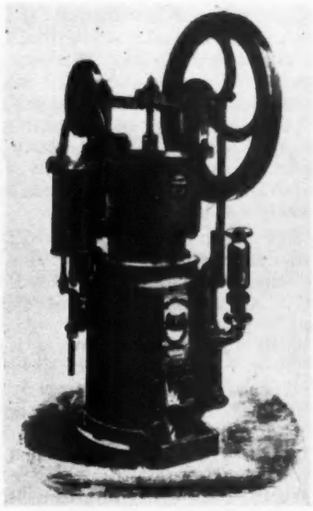

Fig. 13—Reproduction from a woodcut of a vertical hot air pumping engine with integral water pump. Built in substantial numbers between 1860 and 1900

owners seem to have lost patience and had the engine reconverted to what it was originally, namely, a steam engine. It is a great pity that modern engines do not lend themselves so readily to radical changes of working principle—an obstreperous modern diesel engine could hardly be converted to run on steam, or vice versa.

It can now be appreciated that these engines failed to achieve a greater commercial success at that time chiefly because heat-resisting metals were not available for the cylinder bottoms. In steam engine boilers the surface temperature is always kept near the temperature of the boiling water, so that the metal is far less likely to overheat. In air engines a delicate balance between the heat supplied by the fire and that transferred to the working fluid must exist, if the metal temperature is to be kept within its creep strength.

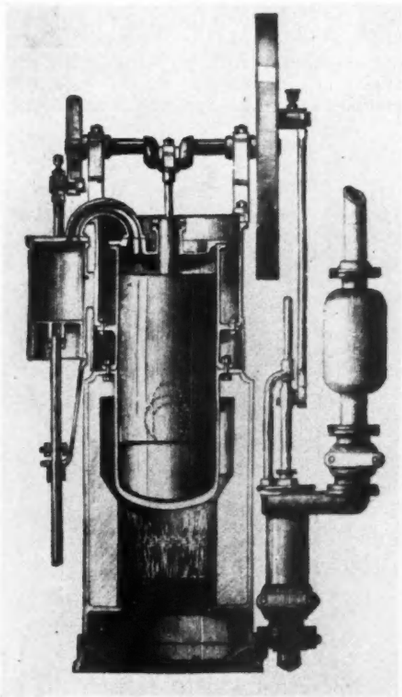

Fig. 14—Cross section through the Bailey vertical pumping engine, showing the extreme simplicity that was achieved. This prime mover had only five main moving parts: crankshaft, two pistons and two connecting rods

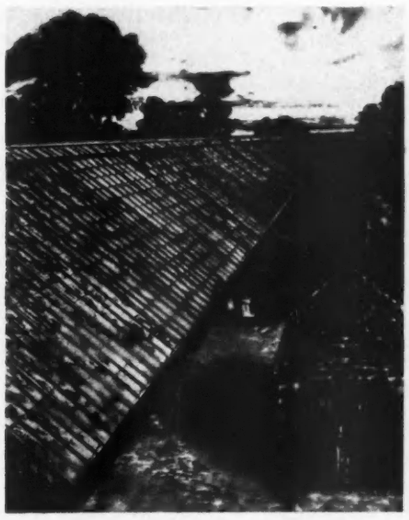

Fig. 15—Reproduction from a woodcut dated about 1890 showing the layout of a greenhouse for tomato growing in Guernsey (Channel Islands) with a vertical hot air pumping engine for the water supply

Apart from the rather limited life of the cylinder bottoms, the performance of these Stirling engines seems to have been quite satisfactory in comparison with alternatives available up to 1850. Stirling claimed an economy in fuel in the ratio of 6 : 26 compared with steam engines.[16] Although this was probably somewhat exaggerated in spite of Stirling's precise numerical formulation, it was generally conceded at the time that under favourable conditions Stirling engines were superior in output and efficiency to available steam engines, in spite of a mechanical efficiency as low as 39 per cent.[10, 21]

Later Double-Cylinder Stirling Engines

Stirling's working principle was used in many different later engines built after 1860 in a number of countries. At first most of these engines used Stirling's second design of 1827, placing the power piston in a separate cylinder, but without making this piston double-acting as in the original prototype. This resulted in a single-cycle, two-piston, two-cylinder construction—a design which had a somewhat lower mechanical efficiency than Stirling's own two-cycle, three-piston, three-cylinder design of 1827, and a very much lower efficiency and output than Stirling's first single-cycle, double-piston, single-cylinder construction of 1816. The main difference between most of these later engines was the position of the power piston in relation to the displacer piston and several alternatives were tried. For example, in the engines shown in Figs. 13–15, the power cylinder is turned upside down, in those shown in Figs. 16 to 19 it is turned through 90 deg., and in Fig. 20 its alignment is the same as that of the displacer cylinder.

In Fig. 13 an early commercial application is shown, which was a compact and simple pumping plant comprising a reciprocating water pump, a prime mover to drive it, and a furnace. This engine was made by Sir W. H. Bailey and Co., Ltd., of Salford, Manchester, who manufactured different types of hot air engines in substantial numbers between 1860 and 1908.

From the cross section shown in Fig. 14 it will be seen that the complete installation has only seven main moving parts. This extreme simplicity made the engine particularly suitable for use by unskilled labour, and it was claimed that no more attention or skill was required than for looking after a slow combustion stove. The link mechanism is considerably simplified, and sliding crosshead guides are used instead of straight-line motions. As in the two-cycle Stirling engines, the displacer moves in a cylinder directly above the furnace, with a passage leading to a separate power cylinder. The water pump is an integral part of this engine and the water is passed through the cooling jackets round the upper portion of the displacer cylinder. This engine is rather primitive and worked without regeneration or raised pressure level and its efficiency could not have been more than a small fraction of that of the original Stirling engine.[17] Fig. 15 shows an early woodcut of such an engine on a farm in Guernsey, Channel Islands, pumping water for tomatoes in a large greenhouse.

Engines of this type were still included in a catalogue of Bailey's as late as 1893. Three different models were then produced with net

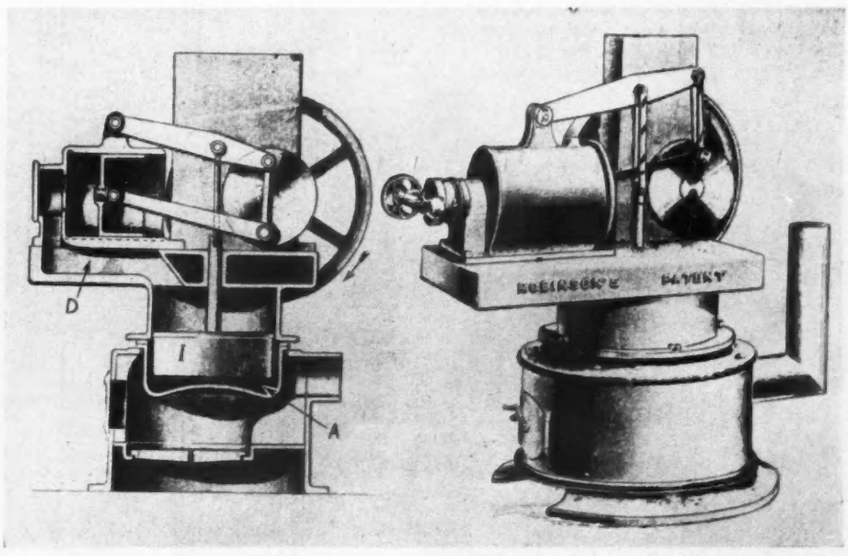

Fig. 16—Cross section and external view of a small Robinson engine with a link driving mechanism commonly advertised in 1895 as a "one manpower motor"

power outputs of $\frac{1}{16}$ h.p., $\frac{1}{8}$ h.p. and $\frac{1}{4}$ h.p. respectively. From the weights given, their specific power ranged from about 7·5 tons per brake horse-power for the smallest to 4·8 tons per brake horsepower for the biggest models, computed from the flow in gallons per minute and the head quoted in the manufacturer's pamphlet.

About that time the "Robinson engine" appeared on the market, which differed from

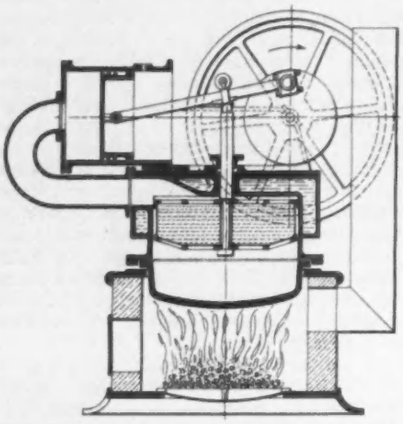

Fig. 17—Cross section through an improved model of a Robinson engine which was fitted with regenerator and a roller drive for the displacer

this early design only in using a horizontal cylinder instead of a vertical one. These engines were made by A. E. and H. Robinson and Co., and under licence by L. Gardner and Sons, Ltd., and Pearce and Co., all of Manchester, between 1895 and 1914. Many thousands of these engines were sold and they became very popular for applications where a small and simple source of power was needed. Such engines could be driven by a small oil lamp or a gas burner instead of using solid fuel, and were frequently referred to in catalogues as "Domestic Motors." These engines also had separate displacer and power cylinders and, as was the case for the engine described previously, were single-cycle, two-cylinder, two-piston designs, but with the cylinders placed at right angles to each other. The last engines of this type were marketed about 1920 by Norris Henty and Gardners, Ltd., of London and Manchester.

An early type of this engine is shown in Fig. 16. This was sold in two models, advertised as the "one manpower motor" and the "two manpower motor" respectively.

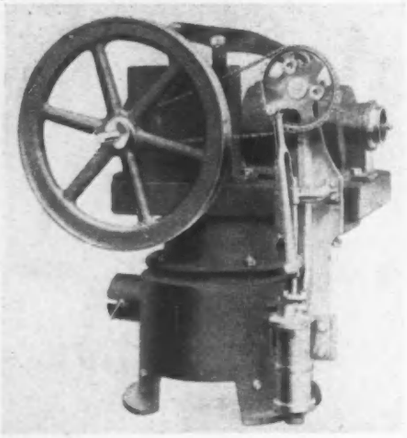

Fig. 18—Coal-fired Robinson engine, *ca.* 1908, with attached chain driven water pump

The displacer *I* and the associated cylinder *A* are similar to earlier designs and here again no regenerator was used. A wide passage *D* leads to the horizontal power cylinder, with a piston driven through a link mechanism

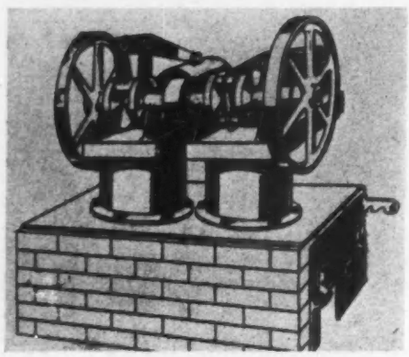

Fig. 19—Inefficient and badly designed two-cycle air engine, made in 1915 by placing two Robinson engines side by side

which results in a phase difference of 90 deg. in the piston movements. A water jacket was fitted at the upper end of the displacer cylinder. The description of this engine also mentions a "safety device" which prevented the engine from racing on light load. This consisted of a light spring-loaded disc interposed in the passage between the two cylinders. Normally this only caused negligible obstruction, but when the engine speed, and hence the air speed, rose too much, this disc closed, until the speed had dropped sufficiently. With no regenerator or raised pressure level, these engines could hardly have produced more than about one-tenth of a horsepower at 150 r.p.m., and the use of this speed limiter or of the curious contraption shown on the left side of the upper cylinder in Fig. 16, which was probably a belt-driven governor, is surprising. The probable explanation is that in the absence of any provision for dynamic balancing, the heavy reciprocating parts might have caused the engines to bounce up and down or topple over at a few hundred revolutions per minute, as there was no visible provision for bolting them to a foundation.

The model shown in Fig. 17 is similar but incorporates a number of detail improvements, the most important being the use of a regenerator made of a mass of thin wire, completely filling the displacer body. The displacer drive is also simplified by using a roller and a slipper pad worked off the connecting rod as shown.

Figures taken from an old catalogue showed that a typical engine about 1ft 11in high weighed 168 lb and produced 0·045 b.h.p. Larger engines of this type delivering up to $\frac{5}{8}$ b.h.p. per cycle were also made later and are shown in Figs. 18 and 19. In Fig. 18 an engine built in 1908 is shown driving an attached pump by means of a chain sprocket, and Fig. 19 shows an example of a two-cycle engine, made simply by duplicating the components on a single crankshaft. This last construction dates from 1915 and it is surprising to find that nearly 100 years after Stirling's invention, engines as primitive as that should still be marketed for industrial applications. One reason for this was that most of these engines were built for export overseas, to countries such as South America, Africa and the Far East.

A very interesting engine of the two-cylinder Stirling type was developed by Laubereau and produced in Berlin by Schwartzkopff about 1860. Initially these were horizontal engines with crank mechanism.[47, 48] In 1864 improved vertical machines with a cam displacer drive were produced as shown in Fig. 20. Again no regeneration was used and the mean pressure level was atmospheric. In addition to these disadvantages, the power cylinder was made to communicate with the hot end of the displacer instead of with the cool end, in order to reduce the dead space in the communicating duct, so that entry of the hot air below the power piston must therefore have increased the difficulties of lubrication. It will be seen from the illustrations that a novel feature of this machine was the use of a cam to actuate the displacer. Such an arrangement has much to recommend it on theoretical grounds, as the ideal cycle can be approached

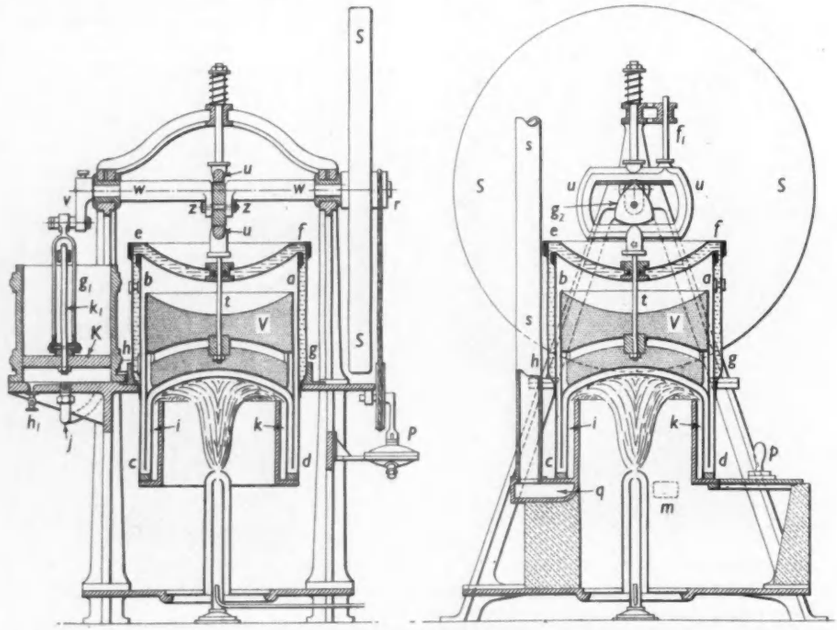

Fig. 20—Cross section through the Laubereau-Schwartzkopff engine, which used a cam for imparting an intermittent drive to the displacer

more closely. In particular, it is possible to make provision for a dwell at dead centre positions. For example, the cam used here imparted upward motion for 120 deg. of crankshaft rotation, rest during 60 deg., downward motion during 120 deg. and rest during the remaining 60 deg. The design of this cam is explained in reference 49 Vol. II, Article 475.

Another improvement in this engine is the use of extended surfaces for heat transfer. A cylindrical flame guide makes the hot gases flow along the surface of the cylinder bottom, and an extension shield is used with the displacer in a way similar to that used on Ericsson's engines, although the illustration is not very clear on this point. The displacer cylinder *abcd* is surrounded by the water jacket *efgh* at its upper end, which formed the cold space. In the lower end, the cylinder was closed by the bell-shaped cover. A hinged bottom cover *p* was provided so that the engine could be run either on solid fuel or by means of an oil or gas burner, as is shown in Fig. 20. The hot products of combustion passed through the space *ik*, through the outlet *m* into *q* and out through the chimney *ss*. The transfer piston *V* consisted of two parts which were made of some poorly conducting material. The displacer cylinder was connected to the power cylinder by means of the pipe *j*. The power piston *K* had a piston rod k_1 working on vertical guides and was connected to the crank *v* on crankshaft *ww* by means of the forked connecting rod g_1. The driving arrangement of the displacer was rather more complicated. Its piston rod *t* passed through the cover of the cylinder through a stuffing box. It is seen from Fig. 20 that the crankshaft *ww* had two small cranks *zz* at the centre, between which a cam of approximately triangular shape g_2 was mounted. This cam moved the rectangular frame *uu*, which in turn was connected to the displacer rod *t* and the vertical guides f_1. Adjacent to the flywheel *SS*, a pulley *r* was fitted to the crankshaft *ww* which drove a small circulating pump *P* for the cooling water. A cock h_1 was provided by means of which the pressure could be released to stop the engine. It was claimed that the speed of this engine was above 500 r.p.m.[50]

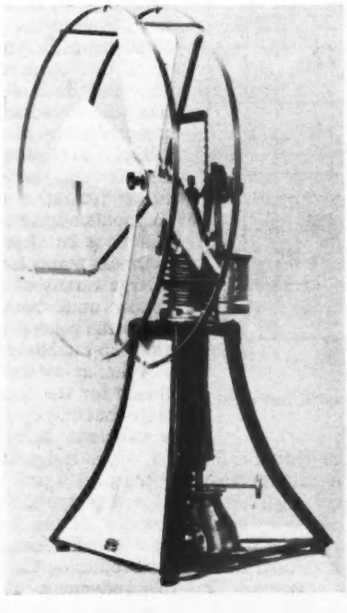

Fig. 21—The "Kyko" portable fan which became very popular in the Far East. Its height is nearly 4ft and it is operated by a paraffin lamp

The "Kyko" portable fan, which is shown in Fig. 21, used to be made in fairly large numbers until recently by the Model Engineering Company for export to tropical countries. It is a self-contained portable fan, about 4ft tall, and will run for twelve hours on 1 pint of paraffin. It achieved considerable popularity among missionaries, traders, planters and well-to-do natives in outlying districts. This fan had the reputation of being virtually foolproof mechanically and ran for many years without attention. The very large blades give a fair air current, as the writer can testify from personal experience. Although made in England, this device is much more likely to be offered for sale in a Far Eastern bazaar than anywhere in this country.

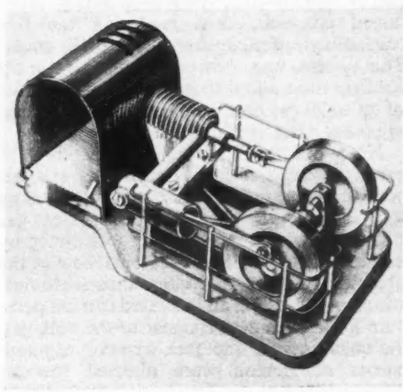

Fig. 22—Small toy air engine in current production for driving small models, complete with methylated spirit lamp

Many thousands of small engines of this type were also produced as toys. Some of these fascinating gadgets, which were often beautifully made, can occasionally still be picked up in junk shops, usually in perfect working order.

The only hot air engine which is still being made to-day in England is shown in Fig. 22. This is a small toy engine, made by Davies Charlton, Ltd., for working Meccano or similar models. Its overall dimensions are 7½in by 4in by 2½in, including a small methylated spirit lamp, which will run the engine for about twenty minutes at 800 r.p.m. on one filling.

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(To be continued)

FERRITES IN RAILWAY SIGNALLING.—A paper entitled "The Application of Ferrites to Railway Signalling Systems" was presented to the Institution of Railway Signal Engineers in London on March 11 by G. R. Cass and J. Sagues, of the Imperial College of Science and Technology. The work described in the paper was a preliminary investigation into the possible use of new electronic components in signal control circuits. Possibilities of errors arise if certain failures occur in thermionic valves, cold cathode tubes and semi-conductor devices installed in the control circuits themselves, but ferrite cores are entirely passive elements and were used exclusively for signal control in these experiments. Transistors provided a power source for the core "gates" to operate, and crystal diodes were incorporated in parts of the circuit which depended on their rectification property, i.e. they acted as rectifiers rather than bilateral resistors. The authors conclude from their work that a system as safe as, and in all probability more reliable than, the present electro-mechanical relay system could be designed at a cost remarkably lower than the relay systems. Preliminary estimates would indicate a reduction in cost by a factor of the order of ten. Refinements such as approach control and locking, and timing circuits were not included in the experiments, but it is stated that their inclusion would not present a major problem.

AVERAGES OF BRITISH RAINFALL, 1916–1950.—The standard 35-year period for averages of rainfall in Great Britain and Northern Ireland which was in general use up to the end of 1957 was 1881–1915. In recent years there has been a growing demand for more up-to-date averages, and there has been increasing difficulty in referring back to the standard because of the decreasing number of rainfall stations still in existence for which observations are available for that period. Work on rainfall averages for a second 35-year period, 1916–1950, reached a sufficiently advanced stage for new averages based on this period to be used for general reference for meteorological data published for January, 1958, and subsequently in the various Stationery Office periodicals on meteorology. The use of the new averages will be gradually extended until the period 1916–1950 becomes fully established as the standard period for rainfall work. All the basis may be regarded as complete and is represented by the data included in a new publication: "Averages of Rainfall for Great Britain and Northern Ireland, 1916–1950," which is now available from H.M. Stationery Office at a price of 4s. 6d. This contains monthly and annual averages for 719 stations, an introduction with brief discussion of the relationships between the averages for the old period and the new, and an index giving the position of each station, both by latitude and longitude to the nearest minute, and by the 100m grid reference appropriate for use with Ordnance Survey 1in to the mile maps. It is expected that this will remain a standard publication, with only minor amendments and additions, for two decades or more.

Engineering Developments in Nuclear Power

In a paper presented to the North East Coast Institution of Engineers and Shipbuilders on February 27, A. T. Bowden, B.Sc. (Eng.), Ph.D., described some of the problems in the design and construction of nuclear power stations and in particular dealt with some of the contributions which have been made in north-east England. These topics include the development of the fuse element, the pressure vessel and circulatory system. Abstracts from this paper are reproduced here.

THE principal design features of the Bradwell station have been published in the technical press and there is therefore no need to repeat them here. As is well known, the reactor is CO_2-cooled, graphite-moderated natural uranium.

The heart of the reactor is, of course, the fuel element and upon its behaviour as to rating and burn-up much of the economy of any given system depends. Restricted as we have been in the construction of the civil reactors in this country to the use of natural uranium, it is necessary, even for plants of large output and therefore with relatively large cores to have the greatest respect for neutron economy ; in fact, the only canning materials available for a natural uranium system with graphite moderation are magnesium, aluminium, zirconium or beryllium. The last mentioned is still in its development stage as a suitable canning material and from strength and oxidation considerations the others are limited in operation to a temperature certainly not exceeding 500 deg. Cent. At the same time the maximum permissible temperatures of the uranium is set by the α—β change point which occurs at some 660 deg. Cent. So, within the field bounded by these two limiting factors—can temperature and central uranium temperature—the challenge is offered to the engineer and it is now possible to reveal some of the developments which have taken place in the last four years at Heaton, on fuel elements particularly suited to gas-cooled graphite-moderated reactor systems and now known generically as the " polyzonal fuel element."

From a nuclear point of view, the greatest economy is observed when large lumps of fuel are used with a minimum surface-to-volume ratio, but from considerations of the temperature limitation already referred to, of fuel rating, of effective moderation, of the highest possible coolant gas temperature for maximum thermodynamic efficiency and of fuel handling, which for civil reactors must be carried out under load, it is necessary to split it up. There are, of course, many ways in which this can be done—single rods, clusters of rods, or tubes. On analysis, it is found that single rods or tubes are the only possibilities in a graphite-moderated natural uranium/magnesium canned system. Tubes show little or no advantage over rods and on account of their more complicated structure are seldom, if ever, used. That leaves single rods ! In the Bradwell design these are 1·15in diameter by 36in long. There are over 2500 channels in each reactor core and eight fuel elements in each channel.

Fuel Elements

The early cans as used in Windscale had longitudinal fins but development work at Harwell and Risley showed that transverse fins, machined on the can at right angles to the coolant flow, gave a considerable increase in heat transfer for a pressure drop still acceptable. Large-scale work in a water-flow simulator showed that this was due to two or three distinct vortices operating in the finned channels, thus rendering the fins reasonably effective down to their roots. The system was, however, sensitive to tip configuration and differences in heat transfer of up to 20 per cent were obtained on reversing the can relative to the gas flow.

Now one of the major difficulties in extracting heat from a finned fuel element with either parallel or transverse finning derives from the fact that the heated gas does not readily transfer the heat either by conduction or mixing to the bulk flow in the channel ; a heated envelope thus surrounds the can, resulting in an increased can temperature for a given heat transfer to the bulk gas. In consequence, the fuel element developments at Heaton were directed towards mixing this hot gas envelope surrounding a finned surface with the bulk stream with the least possible increase in friction. The lead to the solution of the problem had been obtained in work previously undertaken in connection with the direct gas cooling of electrical generator rotors.

The fuel can developed (Fig. 4) has helical fins machined on its outer surface. Longitudinal splitters, three, four or more, extend radially from the body of the can to the wall of the flow channel. The effect of this configuration is that the coolant is gradually consumed in the flutes and is deflected by the splitters and the circular channel in such a manner that a strong vortex is formed which ensures that the hot envelope developing along the fins is merged in the bulk gas stream. There can be no doubt of the revolutionary nature of this conception which already in the short time since it was developed has found universal use in the civil gas-cooled reactors now it building.

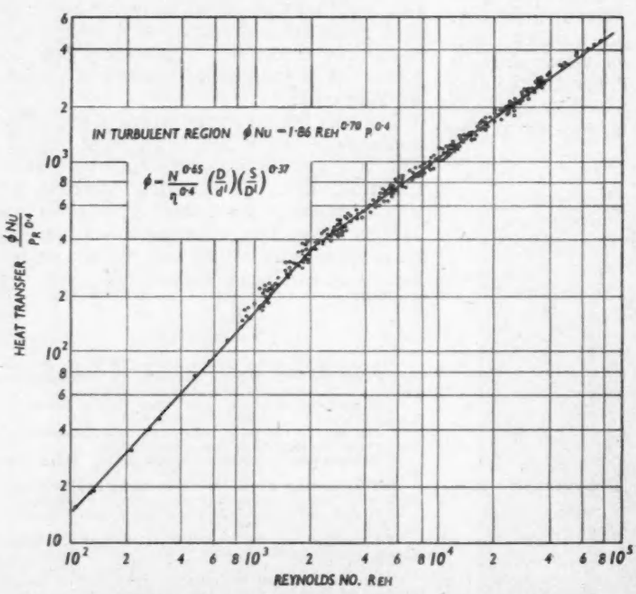
IN TURBULENT REGION $\phi Nu = 1{\cdot}86\, Re_H^{0{\cdot}70}\, P_r^{0{\cdot}4}$
$\phi = \frac{N^{0{\cdot}45}}{\eta^{0{\cdot}4}} \left(\frac{D}{d}\right)\left(\frac{S}{D}\right)^{0{\cdot}37}$
HEAT TRANSFER $\frac{\phi Nu}{Pr^{0{\cdot}4}}$
REYNOLDS NO. Re_H

Fig. 1—General heat transfer correlation for polyzonal spiral fuel cans

The aerodynamic and thermodynamic performances have been intensively investigated against the principal parameters which influence them—channel diameter, splitter height, number and proportions of fins and flutes and the outside and inside diameter of same. Over sixty different combinations have been carefully measured to determine systematically the influence and economic implications of the above variables.

The outstanding results of these investigations are illustrated by the following :

A cylinder of 1·3in outer diameter and provided with thirty-six straight fins of 2·25in tip diameter increases its heat transfer only slightly if the fins are twisted to a lead of 12in. If, however, four longitudinal splitters are inserted into these, the heat transfer goes up by a factor 3 to be set against an increase in friction coefficient of only 4. Unfortunately, the law of diminishing returns applies in so far as the increase in heat transfer slows down with sharper twists, whereas the friction factor goes on rising. With a can of the quoted dimensions it would not, therefore, appear economical to go further than a 16in or 12in lead.

The other remarkable feature of the polyzonal can with its replenishment of the gas in the flutes at regular intervals was found to be that the heat transfer, per unit can length, keeps rising up to a very large number of fins, where the flow between longitudinal fins would long have been choked. Especially when working at high Reynolds numbers, the penalty to be paid in friction factor is small as compared with the gain in heat transfer associated with increasing number of fins.

This may suffice to indicate that a given performance can be achieved in various ways and that the final choice has to be a careful balance among the variables involved. The large number of results obtained made it desirable, if not necessary, to derive a law covering the performance of polyzonal spiral fuel elements in general. Such a law has been found and is represented by the line in Fig. 1 establishing the relationship between heat transfer and Reynolds number. It can be seen that the 500 measurements with a large variety of cans follow quite satisfactorily the general relationship established.

A similar law was obtained for the friction factor but only by using a different definition of the hydraulic diameter, which is significant as it implies that a polyzonal spiral can provide high heat transfers corresponding to the small hydraulic diameter of the flutes, whereas the friction factor benefits from the large annular flow area surrounding the can. This expresses in thermodynamic terms exactly what we had hoped for at the outset of our developments and which is, to our knowledge, quite novel in thermodynamics.

There is still a gulf between the deter-

mination of a principle for a fuel element and its successful behaviour under operating conditions. While the final verdict can only be obtained under irradiation, out-of-pile tests, properly directed, give a good guide to its reliability in service. For example, the polyzonal can developed at Heaton was so strong in its own right compared with the radially finned type used in Calder, that the pressurising process used for the latter to give the necessary intimate contact between can and fuel, was no longer applicable. A hot-oil hydraulic pressure process was eventually evolved which not only pressed the can effectively on the fuel but had at the same time the added advantage of refining the grain structure and thus increasing the ductility of the can material. As will be readily appreciated, this is of considerable importance where the leak tightness of a system is a matter of concern ; the structure obtained in the hydraulic pressurising process reduces the danger of puncturing the wall by the formation of inter-crystalline cavities. Plant has been developed capable of pressurising the assembled fuel element at pressures up to 26,000 lb per square inch and temperatures of up to 250 deg. Cent. In practice, for the design discussed, some 12,000 lb per square inch has proved adequate.

Natural uranium is a poor structural material. Thermal creep at higher and irradiation creep at lower temperatures make for certain bowing under the loading obtaining in the stacked design selected for Bradwell. But the splitters, so essential to the improved heat transfer, seemed admirably fitted to prevent bowing and both short- and long-term rig tests carried out under exaggerated load and temperature conditions proved the effectiveness of this conception.

As mentioned previously, a successful fuel element for a power station reactor must be capable of being charged and discharged under load. This means that it suffers considerable thermal shock in the process, the severity being determined by the temperature difference between the charging machine and the reactor, the time of lowering to position and the rate of flux build-up in the uranium and the consequent heating of the latter. In the polyzonal fuel element it was necessary to consider not only the shock as between can and uranium but the effect of sudden immersion of the splitters into the hot gas.

As originally planned, they had been fitted into tight slots cut in the fins which held them in a radial position and therefore reduced the bending load on the relatively thin sections. Tests showed that under these conditions of restraint the splitters, free at the periphery and held at the can face buckled severely (Fig. 2). The solution adopted was to free the splitters in the grooves and maintain their radial position by braces fitted as shown in Fig. 3. This was completely successful.

There remains the effect of thermal shock at the fuel/can interface due to different rates of heating, thermal conductivity and thermal expansion. This very dangerous phenomenon, which could result in large temperature drops between can and fuel and subsequent overheating of the uranium, is overcome by the use of anti-ratcheting grooves in the uranium into which the can wall is forced during the pressurising process.

The circumferential fins on the Calder cans could only be produced by machining or rolling. The fins on the polyzonal can allowed of the possibility of extrusion. Experiments were begun in 1956 and it is now practically certain that the Bradwell cans will be produced by extruding a straight-finned can followed by a simple twisting operation. The final fuel element, complete with the end fittings which seal the fuel in the can and are designed for support as well as withdrawal, is shown in Fig. 3.

In the introduction to the paper it was noted that the use of beryllium as a canning material was in the development stage. From a nuclear point of view, it is, of course, excellent and if its mechanical properties can be improved as seems likely, it will allow of higher gas temperatures than are now possible with magnesium and, using the flow principle already described, in an appropriately modified fuel-element design, it should be possible to use natural uranium metal. The fuel element shown in Fig. 4 is particularly suited to this conception. It is of sturdy, easily fabricated construction and the heat transfer is excellent. Work is now proceeding on its optimisation.

Fig. 3—Fuel element complete with splitters, braces and end fittings

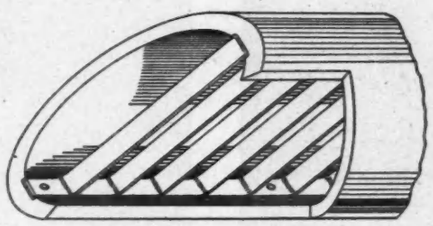

Fig. 4—Ladder fuel element

The Pressure Vessel

The notch-ductile steel used in the reactors at Calder and Chapelcross appears to be capable of withstanding the stress/temperature conditions to which it will be subjected in service, but it would not withstand a higher stress or temperature. As the conditions in the first series of commercial reactors are more severe than in Calder, other solutions of the steel problem had to be found. One group* decided to insulate the pressure shell on the inside so that the temperature would be kept to a level at which a notch-ductile steel could be used. Two groups† decided to use low-carbon, high-manganese, silicon-killed, boiler-quality steel on the grounds that it has better high temperature strength than the alternative type, combined with sufficiently low-temperature notch ductility to meet requirements. The N.P.P.C. group is using a notch-ductile steel for the cooler parts of the reactors and silicon-killed boiler-quality for the hotter parts.

Since the reactors for the present series of commercial nuclear power plants were designed, all the industrial consortia have decided to insulate future pressure vessels so as to ensure that no part of the shell operates above 380 deg. Cent. This avoids the necessity of having to give much attention to creep, and steels for reactor pressure shells can be selected on the basis of weldability, notch ductility at low temperature and tensile strength. It is expected that even if the outlet gas temperature in the plants is raised from its present level of about 400 deg. Cent. to 500–550 deg. Cent., it will still be possible to keep the maximum temperature in the reactor shell to 380 deg. Cent.

Internal insulation of this type, nevertheless, involves some sacrifice of simplicity and at the time of the Bradwell design it was not certain that it would be possible to produce a foolproof and adequate internal insulation. Since then a considerable amount of work has been carried out on a form of insulation consisting of thin dimpled stainless steel sheets alternating with flat stainless steel sheets. The composite insulation is not damaged by irradiation nor will it break up and introduce into the gas stream small particles which must be removed by filtration. The internal insulation of the Latina vessel (Table I) is made up of these alternate layers of dimpled and flat stainless steel sheet and is held in position by a relatively thick mild-steel cover plate secured by studs. Experiments have been made, and are still in progress, to ensure that the characteristics of the insulation under the operating conditions of pressure and temperature in a carbon dioxide atmosphere are known precisely and to ensure that any fixing troubles are eliminated.

As already stated, irradiation raises the notched-bar transition temperature of steel and a considerable amount of work has been done on this during the last four or five years. The effect of irradiation increases with the flux and the time of exposure ; it varies as between one steel and another, and it increases with the temperature of irradiation up to

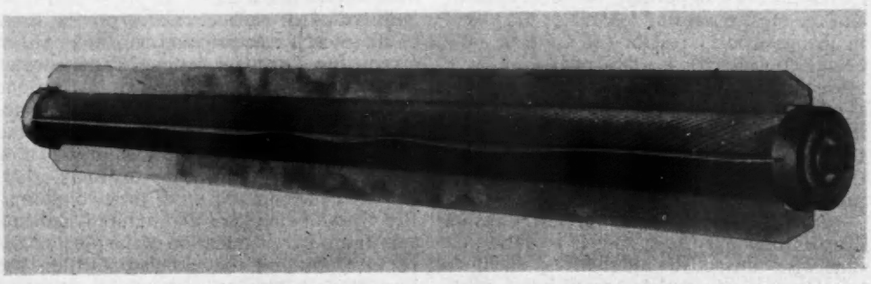

Fig. 2—Can showing splitters buckled by thermal shock

* G.E.C.–Simon-Carves Atomic Energy Group, building the station at Hunterston.

† A.E.I.–John Thompson, building the Berkeley station, and The English Electric–Babcock and Wilcox Group, building the Hinkley Point station.

TABLE I

	Calder	Bradwell	AGIP Latina
Diameter	Cylindrical—37ft 0in	Spherical—66ft 9in mean	Spherical—66ft 9in mean
Length—straight	37ft 0in	—	—
Length—overall	71ft 6in over ends and bottom pip	—	—
Thickness of material	2in	3in and 4in	3$\frac{3}{16}$in and 4$\frac{1}{4}$in
Quality of material	Lowtem (Conlo I)	Bearcomo and Conlo II	Bearcomo and Conlo I
Working pressure	100 lb per square inch	132·3 lb per square inch	182 lb per square inch
Inlet gas temperature	140 deg. Cent.	180 deg. Cent.	180 deg. Cent.
Outlet gas temperature	340 deg. Cent.	390 deg. Cent.	390 deg. Cent.
Design wall temperature	400 deg. Cent.	Designed on 400 deg. Cent.	180–220 deg. Cent.
Internally insulated	No	No	Yes—upper half
Ultimate tensile strength	26/30 tons	26/30 tons	28/32 tons
Weight of reactor	450 tons approx.	1350 tons approx.	1600 tons approx.
Size and weight of core	36ft 0in dia. × 27ft 0in high, 1400 tons with fuel	45ft·9in dia. × 31ft 0in high, 2800 tons with fuel	47ft 6in dia.×31ft 0in high, 3150 tons with fuel
Number of supports	20 at vessel 10 at ground	24 tubular stubs and 24 cols.	24 tubular stubs and 24 cols.

250 deg. Cent.–300 deg. Cent. above which irradiation damage decreases and becomes negligible above 400 deg. Cent. Facilities for irradiation experiments are limited and as time is a factor in the effect, useful tests have to be of some duration. As a result, the amount of information available is small in relation to the number of variables involved which include heat-affected zones and weld metal as well as steel, flux, time and temperature.

There is a great deal of uncertainty with regard to the importance that should be attached to the raising of the transition temperature of pressure-vessel steel under irradiation. It is agreed that a low transition temperature is important to reduce the danger of brittle fracture while a pressure vessel is being built on site. It is also agreed that after the vessel has been stress-relieved by heating at 600 deg. Cent. for about six hours the danger of brittle fracture is very much less than it was before and that after the weld pressure test has been successfully carried out the vessel may be regarded as safe unless something changes. Something does change, however, in that the transition temperature of the steel is raised by irradiation and the question that arises is whether this can bring about conditions more favourable to brittle fracture than those that existed before the vessel was stress-relieved. It is unlikely that an answer to this question will ever be found by experiment, so that suitable measures have to be taken to avoid any danger resulting from it, e.g. by ensuring that no part of the shell ever falls below the highest temperature to which the transition temperature of the steel, weld metal or heat-affected zones is likely to rise, by maintaining the whole of the shell in service at a temperature above that at which substantial irradiation damage can occur or by periodic annealing of the cooler part of the shell.

Until now only different types of mild steel have been used for the construction of pressure-vessel shells and the choice before designers has been whether to sacrifice strength at the operating temperature in order to obtain low temperature notch ductility or vice versa. The steels used have been developed previously for other purposes. During the last three or four years, however, an increasing amount of attention has been given to developing steels for pressure-vessel purposes so as to widen the designer's choice with regard to weldability, low-temperature notch ductility, operating temperature, plate thickness or safe stress. In this work the C.E.G.B., the U.K.A.E.A., the four industrial consortia which are already building nuclear power plants, and several steel makers are collaborating.

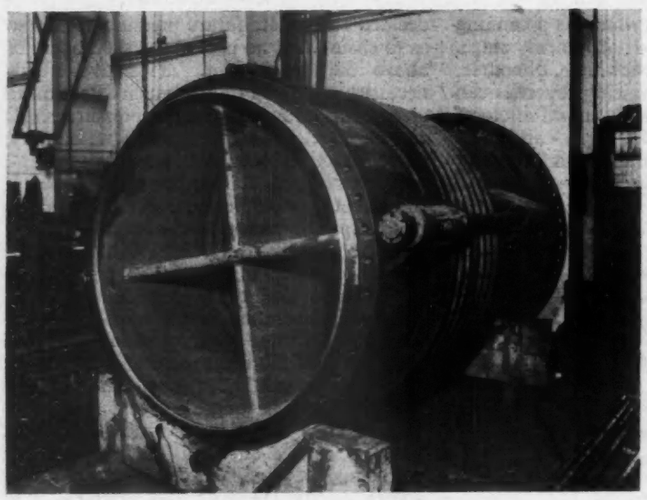

Fig. 5—Tongue design of bellows units

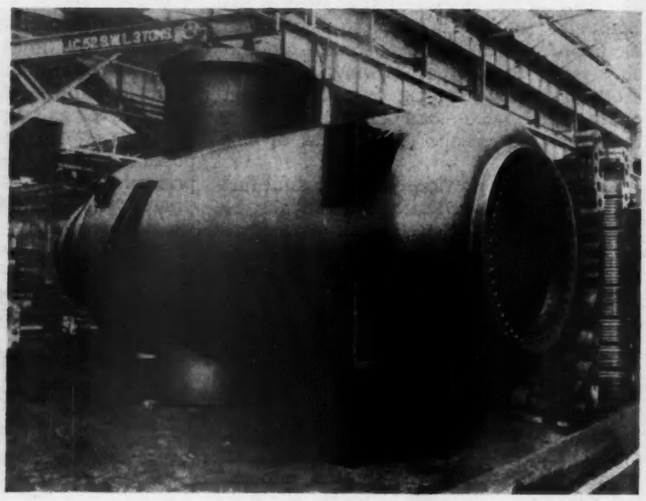

Fig. 6—Casing of axial gas circulator

THE GAS CIRCULATING SYSTEM

With none of the glamour attaching to the fuel element, the reactor and other components, the gas circulating system embracing ducts, valves and circulators is nevertheless one of the most important, the most difficult and the most rewarding. A major drawback to the gas-cooled reactor (of the type now being considered) is the relatively large fraction of the net output—some 10 per cent—required to drive the circulators and there is, therefore, every need and every incentive to reduce pressure losses to a minimum and to maintain the efficiency at the highest practicable level.

In general the dividend for low pressure drop throughout the system is so high that otherwise attractive alternatives such as large-bore or multiple small-bore ducts with pressed or mitred bends or corrugated ducts, give way to single large-bore ducts with three tied bellows in each leg. This was the system selected for Bradwell and while many problems were experienced and overcome on the ducting itself the large tied bellows and large gas valves were the most outstanding developments.

The Bradwell ducts are 60in internal bore and are designed against a pressure of 150 lb per square inch and a maximum temperature of 400 deg. Cent. It will readily be appreciated that the satisfactory design of a flexible bellows unit against such conditions is far from easy. However he may set about the task, the designer is faced with a necessarily concentrated end load of some 200 tons which must be held in such a manner that flexing of the convolutions takes place reliably with a low moment of resistance per degree of tilt and must be transmitted to the duct system in such a way that high local distorting stresses are avoided.

The system used for the Calder bellows unit has a hinged tie in the form of a skirt surrounding the convolutions distributing the load uniformly to the flanges. This design proved expensive and for the conditions obtaining at Bradwell the behaviour in service was considered uncertain. A tongue design based on exhaustive model and full-scale tests and photo-elastic experiments carried out at the Pametrada Research Establishment, was therefore adopted. It is impossible to avoid stress concentrations of quite a high order in any such design and the system adopted simply buries them in the quantity and disposition of the steel used in the construction. The finished unit ready for despatch is shown in Fig. 5.

BRADWELL GAS CIRCULATORS

The mass flow of CO_2 required to extract the design heat output from each reactor is over 5000 lb per second.

The duty of each circulator on the basis of six to each reactor could be met by either a centrifugal or axial design. Experience at Calder and elsewhere has shown that serious difficulties occur in the design and manufacture of large casings to operate under the temperature and pressure conditions now required. This factor, more than any other, coloured the comparison of the two alternative types of circulator and naturally led to a very thorough examination of the possibilities of incorporating the circulator within the ducting or boiler.

It was at once obvious when design calcula-

tions had shown that the required circulator duty could be met by a single-stage axial machine, that a separate casing could be avoided if it were accommodated as an overhung design in the lower end of the boiler.

Construction of the circulator in the lower end of the boiler was finally rejected for the following reasons. In the first place, the inclusion of the axial-flow circulator in the boiler meant an increased height of the latter at full diameter of some 10ft, and produced a difficult problem in reinforcing the shell around the apertures required to accommodate the circulator. Secondly, even with the boiler supported on box girder pedestals at the centre line of the circulator, the relative movements between the independently supported circulator and driving motors, could not be predicted with certainty and would, it was felt, give rise to unacceptable distortion between one component and the other. For these reasons, the present design, in which the axial compressor is housed in a separately constructed pressure vessel, was evolved. It gives most of the advantages of the previous design at no greater cost, with much greater convenience and with calculable expansion movements. It overcomes the very real and largely indeterminate problems associated with the movement of large circulator casings, allows good diffusion, ensures freedom of the compressor from strains set up by connections to boiler or ducting and gives excellent accessibility.

The circulators are designed to provide an overload duty to cater for control of the reactor, and for possible future increases in output. The normal and overload duties are :

	Normal	Maximum
Mass flow of CO_2 in each circulator, lb/sec	903	993
Speed, r.p.m.	3000	3300
Static inlet pressure, lb/sq. in abs	139·9	138·3
Static outlet pressure, lb/sq. in abs	147·5	147·5
Static outlet temperature, deg. Cent. ...	180	180
Static temperature rise, deg. Cent.	5·57	6·73
Adiabatic efficiency, static to static at flange, per cent	82·0	82·0

The pressure casing (Fig. 6) of the circulator consists of a horizontal cylindrical vessel with the gas inlet on top and the gas outlet at the reactor end. The mechanical parts form a unit which is attached at the other end by a vertical flanged joint. The vessel is made long so that the mechanical parts which are bolted to the other end can be handled by the circulator house crane, and so that misalignment caused by pressure or temperature distortions of the vessel due to the very large asymmetrical opening formed by the inlet branch are as small as possible. The vessel is supported at the horizontal centre line. At the reactor end the weight is taken on stools which also locate the casing axially on the centre line of the boiler so as to avoid lateral deflection of the bellows mounted above. The other end of the casing is carried by the circulator body which is in turn supported at the horizontal centre line by a cradle. The unrestrained bellows between the circulator and boiler causes a reaction on the circulator casing which is exactly compensated by a bellows arranged below the circulator diametrically opposite to the inlet branch.

Aerodynamic Design of Circulator

In order to attain a high efficiency with a single stage of axial-flow blading it is necessary to keep the axial velocity as low as practicable and to recover after the blading as much as possible of the head due to that velocity. Furthermore, to reduce the possibility of premature stalling it is necessary to maintain a good velocity profile in the blading. With the arrangement adopted it is necessary to turn the gas either at the inlet or outlet of the blading.

Tests have shown that an accelerating flow of gas can be made to turn a corner with far less total pressure loss and much better velocity profile than a decelerating flow, and it was therefore decided at the outset that the discharge from the circulator should be co-axial with the shaft, so that the diffuser efficiency would be high.

In order to produce the best possible velocity profile at the blading the inlet is made as symmetrical as possible. The gas entering the circulator from the boiler passes into an annular space around the inner lining forming the diffuser and outlet duct of the circulator. It flows axially along the outer annulus and then turns through 180 deg. into the blading. Continuous acceleration is maintained along the annulus and into the blading.

The types of blading that can be used in an axial-flow machine are of great variety, but for this application the choice can be narrowed considerably. In the first place it is clear that to achieve a low axial velocity very high stagger blading must be used. Secondly, blading of the 50 per cent reaction type normally used in British practice is not suitable because it would be necessary to produce a large inlet swirl to the stage, and to remove it afterwards by one or more rows of outlet guide vanes. This would involve high losses which would more than counteract the inherently high efficiency of a 50 per cent reaction stage. Attention was therefore concentrated on blading with degrees of reaction around 100 per cent, in particular the " 120 per cent reaction " type of blading, in which the gas passes through inlet guide vanes which produce swirl in the opposite direction to the rotor blade and leaves the rotor in a substantially axial direction, and the " 80 per cent reaction " type in which the gas passes first through the rotor blades, the resultant swirl being removed by the outlet guide vanes. Of these two types, the lower-reaction blading should, under ideal conditions, be more efficient, but in view of the need for stability of operation under all conditions it was decided to adopt the former blading because the acceleration through the inlet guides would tend to steady the flow into the rotor blades.

Mechanical considerations also confirmed this decision. The inlet guide vanes are mounted at their inner diameter in the circulator body and carry at their outer diameter a shroud ring which extends over the rotor blades. In this way the small tip clearance of the rotor blades is unaffected by distortions of the casing. A disc spring seal prevents gas leakage round the outside of the shroud.

It may be thought at first sight that a peak efficiency of approximately 82 per cent is not very high when compared with multi-stage axial-flow compressor efficiencies of 86 per cent or so, but it must be realised that with single-stage fans, even at very high staggers such as are used here, the inlet and outlet losses form a high proportion of the total losses ; for instance, the loss of one velocity head at the inlet flange is equivalent to a fall in efficiency of about 3·5 percentage points.

The rotor blading is of very low aspect ratio because of the large bending moments imposed by the dense gas, and they resemble the runners of an axial-flow hydraulic turbine or pump rather than conventional compressor blading. Normal methods of blade attachment such as circumferential serrated grooves or axial fir-tree slots are not suitable for blades of such large chord, and the rotor blades are attached as shown in Fig. 7 by steel pins. The stator blades are mounted in conventional circumferential grooves.

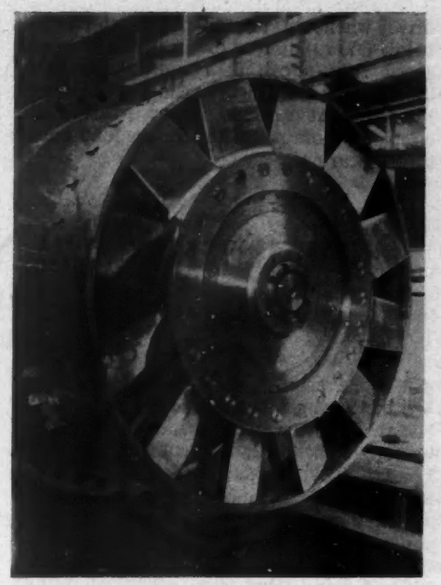

Fig. 7—Rotor of axial-flow gas circulator

Circulator Drive

Two independent driving means are required : a pony motor capable of driving the circulator at 20 per cent speed and a main drive capable of a speed range of 20 to 110 per cent speed. The best type of main drive was the subject of extensive investigations, and turbo-electric was finally chosen as being the most reliable, efficient and easy to control although it is undoubtedly expensive.

Squirrel-cage induction motors are the simplest and most reliable driving units for the circulators and when supplied from auxiliary turbo-generators to enable a speed range to be obtained by variation of frequency, the circulator drive is reduced to a straightforward engineering design of proved reliability. By providing a spare turbo-generator which can be switched to the group of motors on either reactor, a high availability is ensured.

Under normal conditions of operation the motors will be energised and run up from a low speed, but the generator is so designed that when supplying five of the motors at the nominal speed of 3000 r.p.m., the sixth motor may be switched on direct without excessive voltage drop of the generator. The requirement that the generator has to operate over a wide speed range means that the generator terminal voltage must vary substantially in proportion to the frequency to avoid over-saturation of the generator and motor. The voltage regulation is therefore capable of altering the controlled value of the generator voltage in proportion to the generator frequency, which has a range of 10 to 55·3 c/s.

The pony motor is required to circulate gas through the reactor and boilers to raise steam during start-up, and to maintain gas flow during shut-down and in case of failure of the main drive. A ten-pole squirrel cage induction motor connected to a guaranteed a.c. system is used and is coupled directly through an s.s.s. clutch to the circulator shaft. This clutch acts as an over-running coupling and enables the pony motor to take over the

drive whenever the circulator speed falls below 600 r.p.m. and disengages it when the speed rises above that figure. The pony motor has a very high starting torque for its rated output because it has to start the circulator from rest with a heavy load on the thrust bearing.

An additional safety feature of the circulator which caters for simultaneous failure of both main and pony motors and of the reactor safety trips is the flywheel; this is designed to give a long run down time so that the gas flow is maintained through the reactor during the critical period.

Institution of Naval Architects

ANNUAL SPRING MEETING

No. I

ON the morning of Tuesday, March 24, the Spring Meeting of the Institution of Naval Architects was opened in the Weir Lecture Hall at 10, Upper Belgrave Street, London, S.W.1, with the president, Viscount Runciman, in the chair. The secretary gave a summary of the annual report, which announced that Viscount Runciman had consented to continue in office for the period 1959–61, and that the membership had increased by 154 to raise the total to 4214. Two Gold Medals of the Institution were presented, one to Monsieur Paul Gisserot for his paper "Some Problems in Naval Construction To-day," and the other to L. J. Rydill, R.C.N.C., for his paper "A Linear Theory for the Steered Motion of Ships in Waves," while a premium was awarded to Monsieur Jean Dieudonné for his paper "Vibration in Ships." The occasion was also taken to present a silver bell to the Association Technique Maritime et Aeronautique as a memento of the Joint Summer Meeting held in Paris in 1958. The report noted that sixty-six higher level and 162 ordinary level National Certificates in Naval Architecture had been gained, and that the Duke of Northumberland prizes had been awarded to Mr. J. S. Crosbie of Rosyth Dockyard Technical College and Mr. P. C. Clarke of Portsmouth College of Technology. City and Guilds of London Institute prizes were awarded to Mr. B. Reid and Mr. R. Cottage. Conditions governing the award of scholarships were stated to have been under review and that it had been decided to amalgamate the I.N.A., Elgar, Martell and Trewent scholarships to form the Institution of Naval Architects' Scholarship in Naval Architecture. The report also announced that the Institution's Centenary would be celebrated during the week May 16 to 20, 1960, and included notes relating to research work carried out by the British Shipbuilding Research Association, the Ship Division of the N.P.L., Pametrada and the British Welding Research Association.

Following the adoption of the report, Viscount Runciman gave an address, of which we print an abstract.

Address by the President

I should like to make reference to a proposal to set up a new class of membership in this Institution, that of "Student Associates." It has been felt for some time that, while we catch men young on the more highly qualified side and train them or lead them on through Studentship to Associate Membership and, in time, we hope to full Membership of this Institution, there has not hitherto been any comparable group which might attract the younger men who, while not qualifying for full membership, would nevertheless like to become Associates. It is therefore proposed to start a class of Student Associates and this will require a general meeting of the Institution in order that the necessary alterations to Rules may be submitted to the Privy Council.

Another thing we cannot overlook, because it touches us inevitably closely, is the reorganisation within the Admiralty, and the appointment of Mr. Sims as Director-General of Ships. The division of the Controller's responsibilities between ships, weapons, aircraft, dockyards and maintenance appears reasonable, and I hope that it will produce easier and more economical working within the Admiralty. Under Mr. Sims there are ship construction and marine and electrical engineering, and there is everything to be said for grouping these matters together and allowing the Admiralty to seek to solve its problems as those outside it have attempted to solve theirs for some considerable time.

The arrival in this country of the "Methane Pioneer," calls attention to a remarkable and interesting development in the use of ships, and there are good hopes that we shall next year be able to hear a paper on that subject.

Next year is a significant one in our history, since we as an Institution then become 100 years old. Lloyd's Register will be 200 years old next year, and they are proposing to celebrate their bicentenary at much the same time as we are celebrating ours. Also in May the International Maritime Consultative Organisation, which was conceived in 1948 and has taken an unconscionably long time to be born, is to have its first real meeting. We shall then have the international conference on standards of safety and on load line, and I think that before very long we shall have our old friend, tonnage measurement, again coming to the fore.

For the programme of the Institution in our centenary year it is proposed that we should, as usual, hold our Spring Meeting. It is also appropriate that we look back over the developments in the various things for which we exist, over the past 100 years. A centenary year is not a bad one for taking stock, and it has been for a long time in the minds of the Scholarship and Publications Committee that there should be arranged in the autumn of 1960 a symposium on the design of ships, a review, in fact, of the state of the art or science. That, I think, will be a serious piece of work to which we should look forward with keen anticipation.

It is the fact that we have been granted exemption from the payment of rates, under the Scientific Societies Act, 1943. To me, that is important because it shows that a competent and strict tribunal has accepted our claim to be a scientific society. We exist for the objects which differ slightly from those of some kindred societies who set out more than we do to promote the interest of their members. For us, the only benefit which a member can derive from belonging to this Institution is the distinction from being thought worthy to do so. The Institution does not exist for the benefit of its members; the members are allowed to belong for the benefit of the Institution.

After the address by the president, the meeting continued with the reading of the first paper, which was:

SOME THOUGHTS ON DRY DOCKS

By Lieut.-Colonel T. Eustace Smith

Synopsis

The paper considers the ship repairing industry as a whole, including employment level during the last decade and the modernisation trends. Appendices indicate the employed capacity of docks and the time lag before the turnover of large new docks equals that of the smaller units. Problems connected with the building of large dry docks are examined, together with the repair facilities required for large tankers and a short review of dock services and equipment.

Discussion

Mr. E. Leslie Champness, in a written contribution: It is interesting that this Institution has now reviewed this practical question three times in the last six years. There has not been much basic change in our thoughts or in the points ventilated in this period, but private enterprise has got on with the job and the envisaged growth of tankers has become an actuality; we now have "Universe Apollo" afloat, a tanker of 950ft overall length and 135ft beam. We are steadily keeping pace, and in view of these dimensions it may be worth while recording that a dry dock 850ft long (capable of being extended to 1000ft) and 145ft entrance is already under construction on the Tyne. It is foolish to prophesy, but I think we are, for manœuvrability, near the geographical and physical limits of ports and estuaries, as well as the risk involved in such large capital units as the 1000ft tanker.

The appendix, indicating the employed capacity for a 38,000-ton dock, shows in striking fashion what I called in 1953 the "full-employment-white-elephant-problem"—the ship repairer's headache of partial occupation due to the limited numbers of very large vessels as well as the absence of three-shift systems in this country. If the diagrams in the appendix showing the relative annual turnover per square foot of dock were to be amended to show the relative annual return per square foot of original dock cost, the philanthropy of those providing these large dry docks at to-day's costs would be even more evident. It would bring out, I think, the extent to which we are trading on the past and the inevitability of adjusted charges for these new and very large docks to give an adequate return for such major ventures, as would indeed by expected from any other business proposition.

One consolation may be that when others follow suit in later years, it will probably cost even more, and those early in the field deserve a reasonable monopoly reward as partial recompense.

It is to be regretted that one thing remains substantially the same as it was six years ago—that of some expected and necessary relief in taxation considerations—the hope of which is not yet dead and must have played some part in the courage which this industry, standing on its own feet and providing modernity from its own resources, has shown in recent years.

Mr. E. J. Shearer: The appendix relating to the employed capacity of the 38,000-ton dock shows poor utilisation by vessels of a size appropriate to that dock. Does Lieut.-Colonel Eustace Smith think this is typical of most large docks? If so, does this mean that, as more of the larger vessels are commissioned, the relatively small vessels will be "driven out" of the big docks, thus creating a pressure on smaller docks, which at times of average shipping activity, might not be able

to cope with the demand ? After all, far more 18,000-ton tankers are afloat than planned supersizes, and far more big docks than small ones have been built or planned.

Mr. G. A. Bassett : As the author has stated, in dealing with repairs during the war we were definitely handicapped by the lack of big and long docks. We have not overcome the problem yet. With regard to future requirements, I was interested to find details of fifty-seven large tankers which were under construction outside the United Kingdom in February, 1957. Of these, five were of just under 30,000 tons deadweight, length 600ft and beam 84ft ; twenty were between 30,000 and 40,000 tons deadweight, length 630ft–685ft, and beam 90ft to 93ft ; thirty-two were between 40,000 and 87,000 tons deadweight and the beam is L/10 plus 30ft or more. These figures show that the docks as originally designed, deadweight, before the war, having widths of one-tenth of the overall length, are not wide enough.

With the congestion in most repair yards in the United Kingdom, it is difficult to lengthen or widen existing dry docks, and the present tendency is to build new ones. It is necessary also to provide ground space of 25ft–30ft on either side of such a dock for the necessary crane tracks, &c.

Another problem is that of control in moving these very large ships. The forecastle head and the poop head, when such a vessel is in the light condition, is something like 45ft–50ft above the water line, and the tugs which have to handle it have probably about 6ft above the water line. Apart from windage, the tugs will have difficulty in moving such ships in restricted water. Also, when alongside a wharf or in dry dock, special arrangements may be required for access. Something will have to be done about this. It is interesting that the " Queens " take the tow from a deck below the upper deck and are controlled aft from a deck below the upper deck.

Sir Victor G. Shepheard : In the paper it is stated that " it is held by many builders that the greatest bending stress that a ship may encounter will be during the launch from a building berth and with the advent of these very large tankers it may become a serious problem." I am a little surprised to read this and doubtful whether there is evidence to support the statement. In the experience of the British Shipbuilding Research Association full scale measurements during many launches have invariably shown that the stress range is about 2 tons per square inch for moderate size ships. Measurements taken during the launching of a tanker of 11,500 tons deadweight showed that the stresses were about 2 tons per square inch ; and launching stresses measured by the Admiralty Ship Welding Committee on 12,500 tons deadweight cargo ships were about the same figure. The launching stress quoted for the " Queen Mary " was approximately 4½ tons per square inch.

Mr. I. E. King : Strangely enough, at a time when tanker sizes are expanding very rapidly, the Navy's ships will largely consist of smaller types of vessels. A major concern in connection with the aircraft carrier is to deal with the problems which are brought about by the angled flight deck ; the greatest of those problems are on the dock side.

There is another point that if you embark on constructing a large warship of the size of the American aircraft carriers, you will have a tremendous advantage in building the ship in dock, because it enables fitting out to commence almost concurrently with the building of the ship ; therefore it provides about the only practical means of reducing the total time of building to reasonable proportions. I am quite certain that the U.S. Navy could never have succeeded in building such ships as the " Saratoga," which was completed in three and a half years, but for the fact that, the moment they had built the structure which formed the base of the boiler room, the boilers were ready to go in, and the ship was built around them.

There is a paragraph in the paper dealing with the pros and cons of floating docks as compared with graving docks. One of the main virtues of the floating dock in relation to the present problem is that the capital expenditure is much smaller, but these docks are very expensive to maintain. A special virtue of the floating dock in the warship field is that it is mobile. But it requires special berthing arrangements, lack of tide is of advantage, and at least 70ft–80ft depth of water is needed to berth a floating dock capable of taking a ship having a displacement of 60,000 or 80,000 tons.

When planning large docks I would like to emphasise that consideration should be given to the approaches, to entrance across the tide, currents and prevailing winds, and in this connection a wharf for lining up a big ship for taking the entrance would be a good thing.

Could consideration be given to an improved form of keel block ? To-day, if we have to move a section of the keel block in order to clean and paint the keel, the cost is about £10 per block, and it amounts to quite a sum over the full length of a big tanker. The keel is a strength member which we cannot afford to neglect, and the cost of replacement is very high. Could a block be designed which could be removed more cheaply ? The bilge block suggested in the paper is to my mind a necessity. It might mean that these big docks could accommodate two small ships abreast, and we could utilise them a little more economically when they are not required for large ships.

The cleaning of a ship's bottom involves a great deal of time and expense and I feel that ship repairers should make more use of the mechanical appliances available, by which they could do the job more satisfactorily and more quickly than by the methods used to-day. Also I should like to see improved methods for drying out the dock and the ship's bottom before painting.

Mr. J. D. Calder : As we all know, the incidence of unemployment in the ship repairing industry has been much heavier than in the shipbuilding industry. Years ago, if a ship had to be repaired and the contract went to the Continent, the shipowner had to pay the cost of the repair. To-day, however, the picture is different, because the cost to the State is the bill which the shipowner pays to the foreign yard, plus the cost to the taxpayer of the unemployment benefit paid to the unemployed men. If we bear that in mind it might help some of our ship repairers towards a more sympathetic attitude to accepting State assistance. I would not regard it just as assistance to the industry, but as an investment by the country in the industry, because I cannot see, from the financial point of view, how the necessary equipment for dry docks can be obtained without taking a more scientific approach to the taxation problem, or direct State aid.

Mr. J. H. B. Chapman : One would hope to see in these new docks all the modern aids for the correct and efficient treatment of the bottoms of ships, in the form of sandblasting or gritblasting from possibly three points of view. First, the quality of the surface is surely going to be of increasing importance with faster ships ; the better the surface, the less the losses, and the better are the prospects that whatever bottom compositions are applied will stay there. Secondly, with efficient and quick methods the time the ships have to remain in dock can be reduced. Thirdly, the interval between dockings may possibly increase because of the better treatment they receive when they are in dock.

Mr. R. N. Newton : We hear nowadays about future underwater tankers. Supposing we have a surface tanker of 50,000 tons all-up weight, which is about 45,000 tons deadweight, the corresponding submarine would have a deadweight of only 30,000 tons. To start with, the submarine is very much longer, it has an awkward shape, and will need a longer dock. It will also need much more in the way of shoring.

The President : I cannot help feeling that the tendency at the moment towards extremely large tankers may be something of a fashion which will not last all that long. Speakers have indicated how inconvenient, if not actually difficult, it is to handle these tankers and to repair them, and generally to ensure that you do not spend more in keeping them seaworthy than you gain by having large ships to start with. Looking a few years ahead, I am wondering whether there is going to be such a demand for enormous dry docks as some of us are inclined to think. I am also wondering whether the ship repairers may not find themselves obliged, whether they like it or not, to attempt to restrict the number, at any rate for large tankers, just because the provision of the necessary facilities for them is more than the shipbuilders are likely to pay for. or because it imposes a greater burden on the economy of the world at large than will be gained from ships of this enormous size. When we consider the technical aspects, the technical problems of strength, and so on, I wonder how far technical skill outruns commercial prudence.

(*To be continued*)

Obituary

B. J. TERRELL, M.B.E.

We record with regret the sudden death at the age of forty-two of Mr. B. J. Terrell on Friday, March 20.

Basil Joseph Terrell was educated at Truro Cathedral School and took his B.Sc. (Eng.) London Degree after training at Rugby College of Technology and Arts. He served an engineering apprenticeship in the Rugby Works of the British Thomson-Houston Company, Ltd.

In 1938 he joined the English Electric Company, Ltd., as an Assistant Steam Turbine Design Engineer. During the 1939–45 war he served in the Royal Engineers in the Western Desert and later in France, attaining the rank of major and being awarded the M.B.E.

On demobilisation in 1946, he joined the staff of the Parsons and Marine Engineering Turbine Research and Development Association at Wallsend-on-Tyne, on the research side, transferring from the position of Senior Research Engineer to Senior Designer in 1954. In March, 1958, he took up the position of Chief Designer (Future Projects) the position which he held at the time of his death.

He was a member of the North East Coast Institution of Engineers and Shipbuilders and a member of the American Society of Mechanical Engineers. In 1954 he received the M. C. James Gold Medal from the North East Coast Institution of Engineers and Shipbuilders.

LETTERS AND LITERATURE

Letter to the Editor

(We do not hold ourselves responsible for the opinions of our correspondents)

THE USE OF NON-DIMENSIONAL GROUPS

SIR,—I am grateful to Professor Bosworth, who has raised, in his letter in your issue of March 6, some very important points which perhaps have not yet been sufficiently elucidated, or may be in dispute. His letter gives me the opportunity of clarifying and expanding some of the problems.

At the beginning of his letter there is a remark which does not seem quite clear. It refers to the limitations on the manipulation of non-dimensional groups, "any single mathematical combination of numbers, sums, products, &c., can never give the same amount of information as the array of numbers themselves." Does this refer to the component terms of the various groups or the manipulation of the groups? If it refers to each single group and its own components, I would say that only the combined terms of each group have a meaning, as each group is unique and is an entity. If it refers to the last section of my article, it was not my intention to single out one or the other group, as I am fully aware that each group should be applied as a separate tool of investigation without reverting to usual empirical combinations. The complete information required can only be obtained on the basis of these investigations with each group, so to speak, as a specific touchstone.

In his letter, Professor Bosworth has dealt with five main items, classifying some recommendations and limitations on non-dimensional groups under items (*a*) to (*e*). In my reply I will, in general, follow this sequence.

(*a*) The velocity term is restricted to the system of non-dimensional groups of *dynamic similarity*. There are other systems of similarity referring to different problems of physics or engineering (e.g. geometrical, statical and electromagnetical). It does not follow that these groups should include a velocity term as a component part, otherwise the question would arise whether the newly-formed group should not belong to the dynamic system. The velocity term is necessary for all genuine non-dimensional groups of dynamics. The velocity term is a crucial factor in any genuine non-dimensional group of dynamic similarity. If there is no movement or no feature which can be characterised by a velocity, the non-dimensional term is by definition outside the scope of dynamics. "In some of these the stream velocity may be either a minor variable or even a meaningless quantity." This surely means that the intended investigation has no meaning in dynamics and, therefore, should form part of a different domain of inquiry.

(*b*) This item was taken up in the last part of the letter. The problem of mass transfer is usually presented by introducing a diffusion coefficient. The manner in which Professor Bosworth states the related dimensionless term may lead to the assumption, in accordance with my various axiomatic rules, that the Schmidt number represents a genuine non-dimensional group of dynamics, as it may include a velocity term. The Schmidt number is usually given in the following way.

$$\frac{\nu}{D}$$

which shows a close resemblance with the Prandtl number, which is a mere parameter value. D should be combined with ν, as shown in the above ratio. The kinematic viscosity is the characteristic feature of the Reynolds number and, therefore, has no meaning in any other genuine non-dimensional group of dynamics.

A *complete* system of dynamics should exclude all quantities which may be expressed by any of the terms already included in Table II. In addition to specific properties of matter, Professor Bosworth mentions other properties and "constants" which are all outside the domain of dynamics, to which one may add the Stefan-Boltzmann constant. This latter constant may be used as a component in a non-dimensional term, in a distinct and different system of model laws, concerned with radiation problems.

However, there exists another genuine group, which most authorities have not considered at all, viz. the Strouhal number. To neglect this group may result in a serious misunderstanding of the dynamic behaviour of plant. Unfortunately, an unsteady state prevails in many cases, under actual plant conditions. Most of the authors of text books, with the exception of Professor Duncan (reference 5 of my article) omit to mention it. It appears to be known only as a tool for use by the scientist and mathematician, in particular was so used by Lord Rayleigh and G. Birkhoff.[1] Various authorities have used the Strouhal number in a somewhat disguised form without making it clear that the particular term chosen is in fact the Strouhal number. In my opinion this shows clearly the weakness of most methods of dynamic similitude and the derived dimensionless terms, which up to the present have been given as an *incomplete* system of groups. An explanation of this lack of completeness is that "time" (i.e. frequency T^{-1}) being a fundamental unit, has been discarded as an essential independent variable.

(*c*) Professor Bosworth says that in many of the systems (certainly the writer concedes that other systems of non-dimensional terms and model laws may exist), "the absolute distinction between cause and effect disappears, and accordingly there is no absolute distinction between dependent and independent variables." This may be correct in other systems of similitude, but I assume that Professor Bosworth himself agrees that this distinction should be made in a system of genuine non-dimensional groups of *dynamic similarity*, as he says:

"The Stanton Number for the flow of heat from a solid to a moving fluid is the same function of the Reynolds number as is the Fanning coefficient."[2]

As the Fanning coefficient is a typical term comparable to the frictional coefficient, I imply that it is a tool for the investigation of dissipation of energy, e.g. in the case of flow through closed, smooth or rough conduits. This means that the frictional coefficient, the Fanning number and also the Stanton number, in case of heat transfer problems, are dependent variables. This would agree with a statement by the late Professor M. Weber,[3] that the Biot number, which is also comparable with the Nusselt number, is a dependent variable. This can only be varied by changing some conditions which will alter the numerical value of the inter-related Reynolds number. The Reynolds number is a genuine group of dynamic similarity and is always the independent variable.

(*d*) Regarding integral exponents and the interpretation of rheological phenomena by fractional power relationships, I would like to draw attention to a chapter on power laws in a book by Professor M. Reiner,[4] a friend of Dr. Scott Blair.

(*e*) It should be clearly understood that integral exponents and also the three fundamental units are a convention which, in the realm of dynamics, leads to a simple way of presenting a complete system of dynamic units and genuine groups of dynamic similarity. I am not aware that this can be achieved in that particular field by other axiomatic rules with the same ease and completeness. In this respect I would like to quote G. Birkhoff[5]: "in the Newtonian mechanics of fluids, length, time and mass can be taken as independent fundamental units" (page 90). "Newtonian mechanics is invariant under the Galilei Newton group, as well as under the group of transformations of dynamic similitude. Experimentally this principle has been verified in many different ways, with very great precision, except at speeds comparable with that of light" (page 92).

Nevertheless, the velocity of light should not be considered as a pertinent unit of fluid dynamics and thermodynamics in engineering application. I would like to say that both the axiomatic rules of integral powers and the three fundamental units accord with *simplicity of representation*, a procedure and common law for any scientific investigation.

Non-dimensional groups and in particular the method of dynamic similitude cannot reveal numerical values or "constants" without a dimension. This is one of the drawbacks of the method, but it is a serious mistake to say, as other authorities do, that a coefficient or a constant is a function of several non-dimensional groups. I have stressed the point that non-dimensional groups should be considered only as test tools to discover if, over certain ranges of numerical values of particular groups, influences have been observed experimentally. The next task is to establish the limits of those influences and to determine if each group employed has a practical meaning within the particular range of the experiment. I think this agrees well with the last paragraph of Professor Bosworth's letter.

Serious misconceptions regarding the representation of " coefficients " in fluid dynamics have been dealt with recently by the writer in co-operation with W. Stainsby.[6] These investigations show clearly that if the basic equations are not carefully developed, the usual methods of dimensional analysis may lead to the wrong conclusion, i.e. the coefficient of the sharp-crested weir depends on the Reynolds number, whilst it is only related to the Froude number over all practical important ranges.

The methods of dimension, in particular Buckingham's Theorem, can only say that several non-dimensional terms and genuine groups *may* enter the problem. This method can never make a definite statement which of the particular groups or terms are relevant. This is one of the main reasons why I presented a rigid scheme for guidance of investigators. It has to be clearly stated that the purpose of the non-dimensional groups is to find those ranges and conditions of experiment under which one or the other of the groups becomes pertinent. They are employed in experimental investigations because the basic equation is incomplete or cannot be solved. With few exceptions, the non-dimensional groups should be used individually as test tools. Only in trivial cases the non-dimensional group may enter a basic equation as a variable, e.g. in Poiseuille's Law, which may be rewritten, presenting the pressure drop across a capillary as a function of the Reynolds number. From the last paragraph of Professor Bosworth's letter I am sure that we are in agreement in this respect.

F. V. A. ENGEL,
Consultant.

Workington,
Cumberland,
March 5, 1959.

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[4] M. Reiner, *Deformation and Flow : An Elementary Introduction to Theoretical Rheology*, London (1949), H. K. Lewis and Co., Ltd.
[5] G. Birkhoff, *Hydrodynamics, A Study in Logic, Fact, and Similitude*, Princeton (1950), Princeton University Press.
[6] F. V. A. Engel and W. Stainsby, " Weirs for Flow Measurement in Open Channels," *Water and Water Engineering*, Vol. 62 (1958). Part 1 : " On Coefficients and the Velocity of Approach," *ibid.*, pages 142 to 146. Part 2 : " Discharge Coefficient Characteristics Based on Principles of Fluid Dynamics," *ibid.*, pages 190 to 197.

Book Reviews

Some Outstanding Clocks Over Seven Hundred Years. By H. ALAN LLOYD, M.B.E., F.S.A., F.B.H.I. Leonard Hill (Books), Ltd., 9, Eden Street, London, N.W.1. Price 70s.

THIS work, by a writer already well known for his contributions to horological literature, departs from the line of approach taken by many of the books devoted to the history and development of mechanisms for the measurement of time. Instead of describing horology from a historical standpoint and illustrating the account by a series of almost standardised examples, Mr. Alan Lloyd has shaped his book as a series of descriptions of noteworthy time-measuring mechanisms constructed during the past seven hundred years, and has related their historical background to them. In consequence, the book has a freshness that makes it most attractive.

The first clocks to be described are the mercury clock of Alfonso the Wise, constructed in the thirteenth century, and another clock of the same period, made by Robert the Englishman, but neither of these had escapements in the strict sense of the term, and only the barest details are available. There then follows a really extensive description of the clock made by Giovanni de Dondi. As the author remarks, this clock was a masterpiece, and must have excelled any other of similar date. Fortunately, de Dondi left a very complete set of drawings, together with full details of the way it could be constructed, apparently assuming that others of a similar kind would be made. Mr. Alan Lloyd reproduces many of the drawings and much of the description, and after studying these it becomes apparent that Dondi must have been a man of extraordinary brilliance. The remark at the end of the chapter that if a similar clock were to be made to-day, its constructor would be regarded as outstanding, and that Dondi, working with primitive equipment six hundred years ago, merits our homage, is well merited.

The specimens chosen for inclusion in the following pages of this part of the book demonstrate the way in which skill in the construction of clock mechanism was developing, and the remarkable amount of automata and complication embodied in many timekeepers of the period. The examples selected to illustrate such important inventions as the fusee and the pendulum are very good, and a whole chapter is devoted to the unique astronomical clock of Eberhart Baldewin, made about 1561.

Jobst Burgi is another maker who has the distinction of having a chapter of the book devoted to examples of his work. He is principally notable for his invention of the " cross beat " escapement, but he was worthy of praise for his fine workmanship, which is to be seen in his masterpiece, the Vienna Crystal Clock. Mr. Alan Lloyd strikes a parallel between Burgi and Harrison, and comments that they were alike in that they both achieved the highest state of perfection possible at the time. In view of the fame attached to Thomas Tompion, the remark at the end of this chapter that he made no contribution to the improvement of timekeeping except that which was inherent in his excellent workmanship may cause some surprise, but it is, nevertheless, quite true. The author attributes the recoil escapement to William Clement, though he does discuss the claims of Dr. Robert Hooke, and he takes as an example the tower clock made for King's College, Cambridge.

The magnificent work of the " golden age " of clockmaking is represented by some fine examples, and one of the first of the great makers honoured is Tompion, whose two timekeepers with 14ft pendulums, made for John Flamsteed of Greenwich Observatory, are described. Other famous names that appear are Fromanteel, Quare, and Williamson, and in each instance unusual specimens are selected. The same comment applies to the most important invention of the balance spring, for a fine Huyghens clock and a watch by Richard Tils, of London, illustrate it in early form. The famous dead-beat escapement, the invention of " Honest George Graham " is dealt with, but it seems strange that no example of a clock fitted with it is included.

Although repeater mechanism is only rarely to be found in use in these days, it was a remarkable invention in its day, and is, to some extent, the basis of the modern telephone dial mechanism, so it is fitting that the earliest known minute repeater, a table clock, should have its place. It was made by Benedict Furstin Felder, of Freiburg, about 1705.

The name of John Harrison is so famous that it is not easy to find a clock of his make that is little known, but Mr. Alan Lloyd has included two. One is a very fine wooden tower clock still at work at Brocklesbury Park, Lincolnshire, and the other a fine regulator, made for his own use.

Continental makers are not forgotten, and some really unusual clocks are included in the thirteenth chapter. It is notable, however, that makers on the Continent seem to have devoted themselves more to the production of novelties than to improvements in timekeeping, at any rate, so far as the eighteenth–nineteenth century period is concerned.

At the beginning of the last chapter Mr. Alan Lloyd makes the very pessimistic statement that, " The time of the love and pride of craftsmanship has passed." That such despondency is not entirely justified is proved by the fine workmanship to be found in the Shortt free pendulum clock, and in some of the excellent tower clocks still being made by a number of makers. Perhaps it would be more correct to say that fine craftsmanship is not the exclusive perquisite of any age. The specimens shown in this book are, in the author's own words, " outstanding," and there were many rough and uninspired mechanisms produced at the time that they were made. Mr. Alan Lloyd has chosen the best—but there were others ! There are also some fine clocks being made to-day, and these can be found if one looks hard enough.

The author pays tribute to the work of Rudd and Shortt in connection with the perfection of a free pendulum clock, and he also includes mention of the Atmos clock, which is wound by barometric changes. For sheer novelty, it would be hard to beat the Earl of Meath's water clock, which is very fully described, and has mechanism strongly reminiscent of the productions of Heath Robinson and Emmett. Clifford's magnetic escapement is also dealt with, and, indeed, should be, for it is most ingenious, and is a device of which the last has, most certainly, not yet been heard.

Finally the author describes the magnificent astronomical clock made to the designs of Robert d'E. Atkinson for York Minster. The skill and good workmanship put into this clock somewhat disprove Mr. Alan Lloyd's despondent views on present-day clocks. A glossary of a very useful kind and a carefully compiled index complete the book, which is worthy of a place on any bookshelf of horological works.

Rock Pressure in Mines. By E. DE ST. Q. ISAACSON. Mining Publications, Ltd., Salisbury House, London, E.C.2. Price 45s.

THE author of this small textbook is the officer-in-charge of the Rock Pressure Research Unit, Government of Mysore, Kolar Gold Mining Undertakings. The book is intended for the use both of advanced students of mining and of engineers in charge of deep workings. It is particularly valuable and timely because it draws on the results of many reports of researches in deep mines carried out in recent years in South Africa, Canada, India, the U.S.A., and Great Britain, and utilises their findings on this increasingly important subject of rock pressure.

As a preliminary the author gives a brief account of the behaviour of solid specimens of homogeneous and isotropic rock subject to stresses and strains within the elastic limit. He then shows how these elastic stresses and strains are affected by openings of circular or

other symmetrical shape which can readily be treated mathematically. This he does by stating the appropriate formula (taken from the works of the authorities on the subject) and then explaining its meaning in a concise and convincing way with the aid of diagrams which help one to visualise the effects produced. The author is to be congratulated on this method of treatment ; it avoids the mass of preliminary equations which so often cloud rather than clarify these subjects for the normal reader, especially for a practical mining engineer.

The behaviour of homogeneous rock when stressed beyond the elastic limit is then discussed. The influence of the regions of " plastic deformation " and of " plastic flow " on the distribution of stress and strain and in modifying the effects indicated by simple elastic theory is then explained by means of examples of elementary shapes of openings in the solid rock as before. Shear stress diagrams are used to illustrate the distribution of this stress around such openings, and to emphasise its all-important role in inducing failure.

After this survey of the basic theory of the subject the author deals with the modifications required to cope with lack of homogeneity in the rock, e.g. stratification, faults, dykes, and the variation in the elastic modulus with direction of loading which many rocks exhibit. In the latter case he states that " the theoretical discussion of stresses around an opening becomes extremely complex and the resultant equations are sufficiently unwieldy as to be all but useless to the practical mining engineer "—and to many other engineers, one suspects. The application of the theory of bending to the roof of a road when the stratification of the rock permits is discussed at length, as is also the potential influence of a fault on the distribution of stress around a road or working face which is approaching it.

In the next two chapters the author shows how the various theoretical concepts can be used to guide the design and layout of workings ; first, of development work, such as shaft siting and sinking, and the planning and driving of main roads ; secondly, of the system of stoping used for the extraction of the mineral.

The recommendations are made solely to minimise undesirable pressure effects and to ease the control of inevitable ground movement following mining operations. The mining engineer in charge will have a host of other matters to consider, and he must often compromise between several ideal individual solutions. For example, the choice between a circular, rectangular, or elliptical cross section of a shaft depends on several factors in addition to the lateral ground stress induced at its periphery at a depth of 10,000ft. On the subject of shaft linings it is considered that a monolithic reinforced concrete lining with brickwork ring partings at about 10ft intervals will usually prove most satisfactory for all sections of shaft, and the use of a compressible filling between the rock and the lining can have only limited use. The author states that all development work in advance of current stoping should be restricted to a minimum in order to avoid long-time strain effects which will cause trouble when extraction begins. On the other hand, he recommends that the rate of advance of stope faces should be restricted to allow time for the rock to deform gradually and so relieve itself of some of the stress induced in it as the face advances. Much of the section on planning and working of longwall stoping systems is derived from Spalding's book *Deep Mining ;* the author gives a useful summary of the principles of this subject, and of pillar extraction.

Rock bursts are one of the major problems in deep mining ; a big rock burst is equivalent in its effect to a huge explosion in the workings. Obviously a better knowledge of the causes of rock bursts will help in avoiding them all, both large and small. As the author states, they all result from failure of the rock in shear and he proceeds to show how these stresses can be reduced by suitable planning. Several selected examples of rock bursts are used to illustrate their probable origins and to suggest how they might be avoided.

In the last chapter the author gives brief descriptions of various measuring instruments for use underground. They include simple mechanical devices to measure closures in ways and workings, and more precise and complicated instruments to read strains in the face of the rock, including electric resistance gauges and the sonometer. Two instruments for measuring the stresses within the rock mass are described, one using the velocity of sound, and one the variation in electric resistivity, both of which vary with the pressure in so far as that affects the value of Young's modulus.

The three appendices to the book deal briefly with the physical properties of rocks and supports, the dome theory of roof movement over an excavation, and the mathematical theory of probability applied to rock failure.

The book is well produced in clear type with 125 figures and four plates, the index is adequate, and it gives numerous references to many other books and reports. It is commended as a useful survey of the theory of rock pressure and a guide to its application underground.

Steam Turbine Performance and Economics. By ROBERT L. BARTLETT. McGraw-Hill Publishing Company, Ltd., McGraw-Hill House, 95, Farringdon Street, London, E.C.4. Price 97s.

IN his foreword to this book, Mr. Glenn B. Warren, vice-president of the Turbine Division of the General Electric Company of America, says : " This book is aimed particularly at permitting determination of accurate answers on relative power-plant performance, and the economic worth of alternative designs, as well as providing up-to-date methods and data in a form useful both to practising engineers and to students. It should promote beneficial study and discussion in universities and among consulting engineers by providing modern data with which to attack to-day's, and to-morrow's, power-plant cycle problems." There is no doubt that the book meets these requirements admirably, although, as Mr. Warren later says, it will probably be obsolete in its own turn before many years.

The first few chapters discuss the characteristics of steam turbines and provide a general introduction to power plant design and arrangement, concluding with the preparation of typical heat balances. This is followed by a chapter on the factors underlying the calculation of the internal efficiency of steam turbines. From here, the author goes on to make a study of the comparative differences in performance between cycles of various arrangements, steam conditions and types of turbine. This is followed by a very good chapter on gas turbines and the combined steam turbine/gas turbine cycle, written by R. C. Sheldon, a cycle with very considerable potential advantages which seems to be lying somewhat in the doldrums at present. Four short chapters at the end are devoted to the economic evaluation of a given cycle and the author has been courageous enough to deal not only with running costs and capital costs, but also with operation and maintenance costs. Although these chapters are related to the American financial system which differs slightly from that in this country, the information given is both interesting and useful.

The book is amply illustrated by curves and diagrams and the writer feels that to some extent it supplements the previous work, *Steam Turbines and Their Cycles*, by J. Kenneth Salisbury, also of the General Electric Company of America in New York. As in any book of this kind, many simplifying assumptions have to be made with which everybody may not entirely agree. On the other hand, the book contains a great deal of information which is usually kept under lock and key by the designing firm and is, therefore, most valuable as a basis of comparison to any engineer working in the same field.

It is not, one would think, a book for the undergraduate student, but one which will primarily be read and critically discussed by the practising turbine engineer, the power-plant consultant and the post-graduate student specialising in the power-plant field.

Lehrbriefe für Kältetechnik, Nos. 6–10. Edited by H. WEIMAR. Karlsruhe : Verlag C. F. Müller. Price DM.7·70.

THE present publication continues the series of instruction leaflets issued on behalf of the German Refrigeration Industry Working Group and the Bavarian Refrigeration Technology Group. Nos. 6–10 deal with plane geometry, various physical properties and their measurement, substances used in refrigeration, steam tables, the slide rule, and the principles of refrigeration.

I, x-Diagramme feuchter Luft. By MAX GRUBENMANN. Berlin-Göttingen-Heidelberg : Springer-Verlag, Berlin-Wilmersdorf, Heidelberger Platz 3. Price : DM.15.60.

NOW appearing in a fourth revised edition, the present collection of Mollier diagrams for moist air will be found useful by chemical engineers as well as all those dealing with heating, ventilating and air conditioning. The diagrams are set out very clearly and designed to facilitate the solution of practical problems. The theoretical basis, and the chief applications, are fully discussed in the text.

Books Received

Electrical Year Book, 1959. Emmott and Co., Ltd., 31, King Street West, Manchester, 3. Price 3s. 6d.

The Growth of Industrial Economies. By W. G. Hoffmann. Manchester University Press, 316-324, Oxford Road, Manchester, 13. Price 25s.

Aircraft and Missile Propulsion. Volume 2. By M. J. Zucrow. Chapman and Hall, Ltd., 37, Essex Street, London, W.C.2. Price 104s.

Surface Defects in Ingots and their Products. Second Edition. The Iron and Steel Institute, 4, Grosvenor Gardens, London, S.W.1. Price 25s.

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Theory of Machines. 3rd Edition. By B. Brunel Low. Longmans, Green and Co., Ltd., 6 and 7, Clifford Street, London, W.1. Price 25s.

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Elementary Matrix Algebra. By Franz E. Hohn. The Macmillan Company, New York, South Audley Street, London, W.1. Price 52s. 6d.

Experimental Investigations on Stick-Slip Sliding

FLUCTUATING VELOCITY-DRIVE AND FORCED VIBRATIONS

By B. R. SINGH, B.Sc. (Engg.) (Hons.), M.Tech.*
and H. B. MOHANTI, M.Sc.*

It has been shown that the critical velocity of sliding of an elastic system driven with a fluctuating velocity under boundary friction is influenced by the frequency and the amplitude of the fluctuation. Again, the critical velocity of the elastic system is affected if the sliding mass is subjected to forced vibration. From results obtained on an electric analogue computer, it appears that the critical velocity is considerably increased when the frequency of fluctuations or that of impressed force resonates with the natural frequency of the elastic system. At higher frequency ratios, the fluctuating drive does not appear to influence the critical velocity although in the case of forced vibration it was observed that the critical velocity was considerably decreased. It is thus concluded that where stick-slip effects are to be eliminated, resonant vibration should be avoided, while high-frequency forced vibration may be employed to advantage.

IT is well known that an elastic system sliding at a steady velocity lower than a critical value executes stick-slip vibrations. Theoretical and experimental investigations on this problem have been reported in earlier

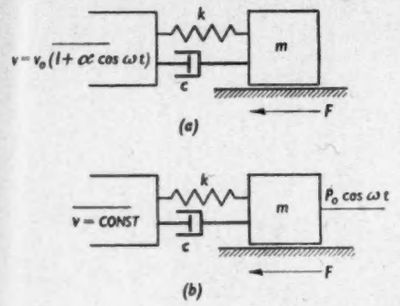

Fig. 1

papers.[1, 2, 3] However, in most practical cases, the velocity of drive may fluctuate at a certain frequency, or the sliding mass may be subjected to forced vibration.

Consider an elastic system as shown in Figs. 1 (*a*) and 1 (*b*). Here the sliding mass *m* is

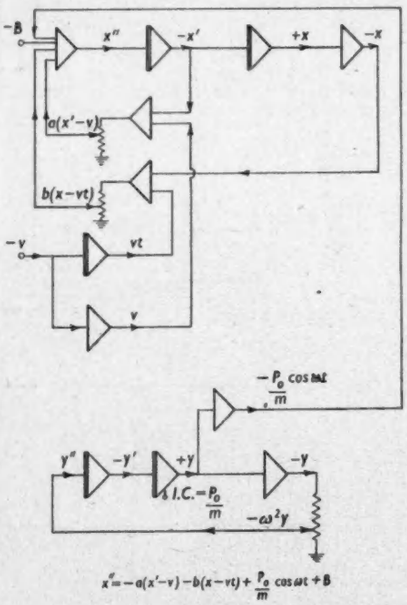

Fig. 2

driven by a drive coupled by a stiffness *k* and an equivalent viscous damping constant *c* for the system. In Fig. 1 (*a*), the velocity of drive that fluctuates with time is given as $v=v_0(1+\alpha\cos\omega t)$ where : v=instantaneous velocity of drive, v_0=average velocity of drive, α=ratio of amplitude of fluctuations to the average velocity ; and ω=angular frequency of fluctuations. The equation of motion of the mass during slip may be written[4] as,

$$mx''+cx'+kx=\Delta F+v_0(1+\alpha\cos\omega t)(c+kt) \quad . \quad . \quad . \quad . \quad . \quad (1)$$

where $\Delta F=F_0-F$, the difference between the static and kinetic frictional resistances between the sliding surfaces.

In Fig. 1 (*b*) is represented the elastic system driven at a uniform velocity but the sliding mass is subjected to an alternating force $P_0\cos\omega t$, where P_0 is the maximum amplitude of applied force and ω=the frequency of fluctuations. The equation of motion of the mass during a slip in this case[5] is represented by

$$mx''+cx'+kx=\Delta F+kvt+vc+P_0\cos\omega t \quad . \quad . \quad . \quad . \quad . \quad (2)$$

The critical velocity of stick-slip sliding for both of the foregoing cases is investigated by simulating the arrangement on an analogue computer. The simulating schemes and the results obtained are presented in the succeeding sections.

Simulation of Fluctuating Velocity

For the computer[6] set-up, the relation (1) for the case of fluctuating velocity drive can be arranged as

$$x''=-\frac{c}{m}v_0-\frac{k}{m}x+\frac{k}{m}v_0t+\left(\frac{c}{m}v_0+\frac{k}{m}v_0t\right)\alpha\cos\omega t$$

$$+\frac{\Delta F}{m}-\frac{c}{m}x'=-\frac{c}{m}(x'-v_0)-\frac{k}{m}(x-v_0t)$$

$$+\left(\frac{c}{m}v_0+\frac{k}{m}v_0t\right)\alpha\cos\omega t+\frac{\Delta F}{m} \quad . \quad . \quad . \quad (3)$$

It is necessary to introduce time scale-factor in the relation (3) to slow down the computer solution of the problem for the best operation of the servo-driven plotting device employed in these tests. The amplitude scale-factor for the problem has been chosen to keep the voltages in the computer within its operating range and also not too low for determining the critical velocity for accuracy. From relation (3) we have,

$$X''=-a(X'-v_0)-b(X-v_0t)+(av_0+bv_0t)\alpha\cos\omega t+B \quad . \quad (4)$$

where,

$$a=c/mS_t,\ b=k/mS_t^2,\ B=\frac{\Delta F}{m}\frac{S_v}{S_t^2};$$

$$x=X\,.\,S_v\ ;\ S_v \text{ and } S_t$$

are amplitude and time-scale factors respectively.

The computer set-up for the relation (4) is shown in Fig. 2. The cosine term is simulated by setting up the second order differential equation for simple harmonic motion, i.e. $y''=-\omega^2y$; and the initial

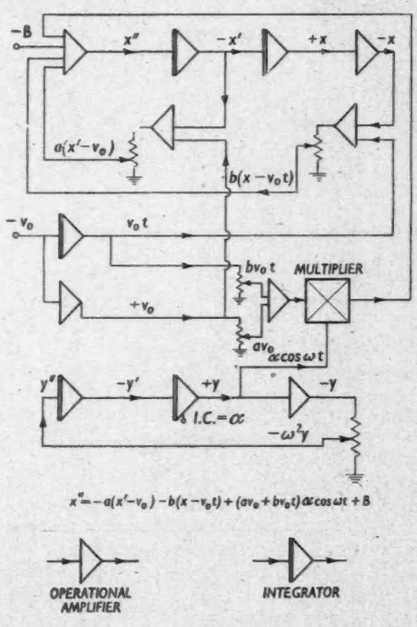

Fig. 3

Table I—v'_c (*Fluctuating Drive*) *Inch Per Second*

ξ	0·1			0·2			0·3		
α / f (c.p.s.)	0·10	0·15	0·25	0·10	0·15	0·25	0·10	0·15	0·25
0	0·5	0·5	0·5	0·36	0·36	0·36	0·33	0·33	0·33
7·25	1·05	1·5	2·3	0·75	1·1	1·65	0·66	1·1	1·45
24·2	2·20	3·50	5·0	1·25	2·15	2·88	0·92	1·65	2·01
48·2	1·6	2·35	3·3	0·94	1·5	2·16	0·67	1·32	1·72
97·0	1·1	1·3	1·4	0·72	0·86	0·94	0·62	0·76	0·79
121·0	0·9	0·9	0·8	0·6	0·62	0·54	0·52	0·61	0·61
242·0	1·4	1·4	1·4	0·51	0·51	0·51	0·47	0·47	0·47

* Indian Institute of Technology, Kharagpur, India.

TABLE II—*(Forced Vibration)* V'_{c_1} *and* V'_{c_2} *(Inch Per Second)*

P_0 (lb)	0·05		0·1		0·25		0·5	
f (c.p.s.)	V'_{c_1}	V'_{c_2}	V'_{c_1}	V'_{c_2}	V'_{c_1}	V'_{c_2}	V'_{c_1}	V'_{c_2}
0	0·50	0·50	0·50	0·50	0·50	0·50	0·50	0·50
7·25	0·69	0·60	0·80	0·75	1·15	1·0	1·8	1·75
24·2	1·07	1·10	1·35	1·4	3·5	3·75	6·65	6·5
48·4	0·55	0·50	0·50	0·6	0·5	0·55	0·45	0·5
9·70	0·27	0·25	0·24	0·23	0·18	0·17	0·14	0·15
121·0	0·24	0·23	0·22	0·70	0·09	0·10	0·08	0·07
242·0	0·22	0·20	0·20	0	0·04	0·05	0·08	0·03

TABLE III—*(Forced Vibration)*, V'_c *(Inch Per Second)*

ξ	0·2				0·3			
P_0 (lb) / f (c.p.s.)	0·05	0·1	0·25	0·5	0·05	0·1	0·25	0·5
0	0·36	0·36	0·36	0·36	0·33	0·33	0·33	0·33
72·5	0·40	0·42	0·015	1·075	0·35	0·36	0·5	0·66
24·2	0·45	0·85	2·0	3·6	0·46	0·66	1·32	2·75
48·2	0·35	0·35	0·32	0·32	0·30	0·32	0·30	0·30
97·1	0·17	0·14	0·10	0·10	0·13	0·12	0·09	0·07
121·0	0·15	0·125	0·07	0·63	0·11	0·10	0·07	0·05
242·0	0·12	0·10	0·03	0·018	0·09	0·07	0·02	0·17

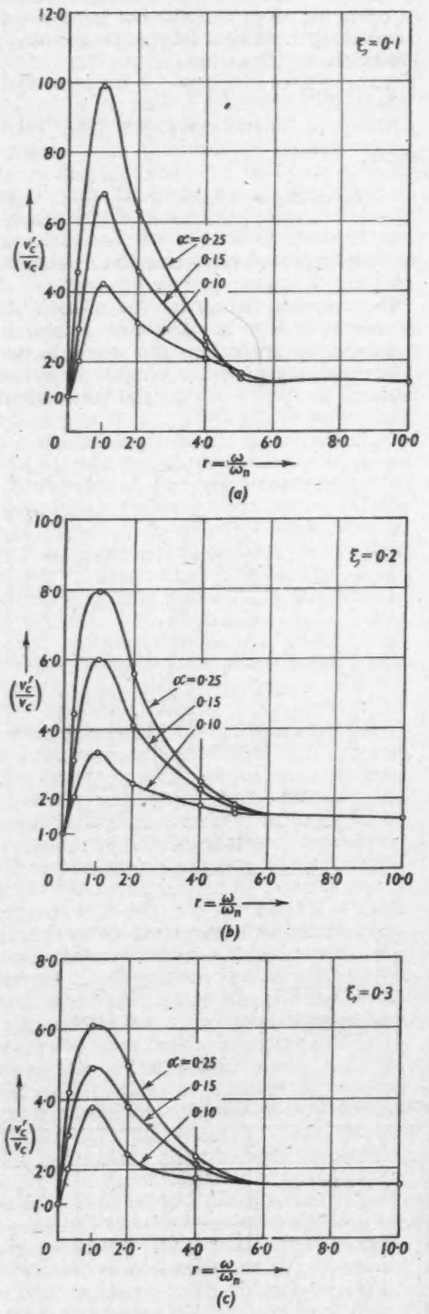

Fig. 4

conditions are, at $y=\alpha$, $y'=0$. The computer set-up for this is shown in the lower part of Fig. 3 and under these conditions $y=\alpha \cos \omega t$ is simulated. A function multiplier has been used in the computer to multiply $\alpha \cos \omega t$ with (av_0+bv_0t).

The values for a, b, B and ω^2 are calculated by proper substitution from the values given in Table I. The time and amplitude scale-factors have been taken as 300 and 100 respectively for convenience. Then the critical value of the velocity of the fluctuating drive v_0 has been determined by varying the input voltage v_0 in the computer set-up. The results obtained in this method are shown as V'_c in the Table I.

SIMULATION OF FORCED VIBRATION

The relation (2) represents the stick-slip sliding under forced vibration. For the convenience of the computer, the relation may be arranged as,

$$x''=-\frac{c}{m}(x'-v)-\frac{k}{m}(x-vt)+\frac{P_0}{m}\cos \omega t+\frac{\Delta F}{m} \quad . \quad . \quad . \quad . \quad . \quad (5)$$

Employing the time and amplitude scale-factors, this relation may be written,

$$X''=-a(X'-v)-b(X-vt)+B' \cos \omega t+B \quad . \quad . \quad . \quad . \quad . \quad (6)$$

where

$$a=\frac{c}{mS_t},\ b=\frac{k}{mS_t^2};\ B'=\frac{P_0}{m}\frac{S_v}{S_t^2},\ B=\frac{\Delta F}{m}\frac{S_v}{S_t^2};$$

$$x=X \,.\, S_v;\ \text{and } S_v \text{ and } S_t$$

are amplitude and time scale-factors. The cosine term is simulated by setting up the second order differential equation as before. The computer set-up for this case is shown in Fig. 3. The critical velocity under forced vibration was obtained by varying the input voltage. The results thus obtained are shown in Tables II and III.

RESULTS AND DISCUSSION

In Table I are represented the results obtained from the electric analogue computer, for the critical velocity under fluctuating drive. Thus, for a typical case with a spring scale $k=300$ lb per inch, $W=5$ lb, the undamped natural frequency is 23·9 c/s. For different damping ratios of $\xi=0·1$, 0·2, and 0·3 ; and with $\alpha=0·1$, 0·15, and 0·25, the frequency of fluctuation ω was varied. The results so obtained are plotted in Fig. 4 in a graphical form in terms of non-dimensional parameters, with V'_c/V_c the ratio of critical velocity in fluctuating drive to that without fluctuations ; against the frequency ratio ω/ω_n ; for different values of the parameter and the system damping ratios ξ.

It will be clear from these results that at higher frequency ratios 5 or more, the critical velocity under fluctuating drive is approximately $\sqrt{2}$ times its value for the case without fluctuations. However, when the frequency of fluctuations resonate with the natural frequency of vibrations, the critical velocity may be considerably increased, depending upon the percentage of the magnitude of fluctuations. Thus, for 25 per cent fluctuation in the magnitude, for a damping ratio of 0·1, V'_c/V_c at resonance is 10·0. The influence of damping on the critical velocity at resonance is to lower the critical velocity as will appear from the Fig. 4.

In Table II are presented the results

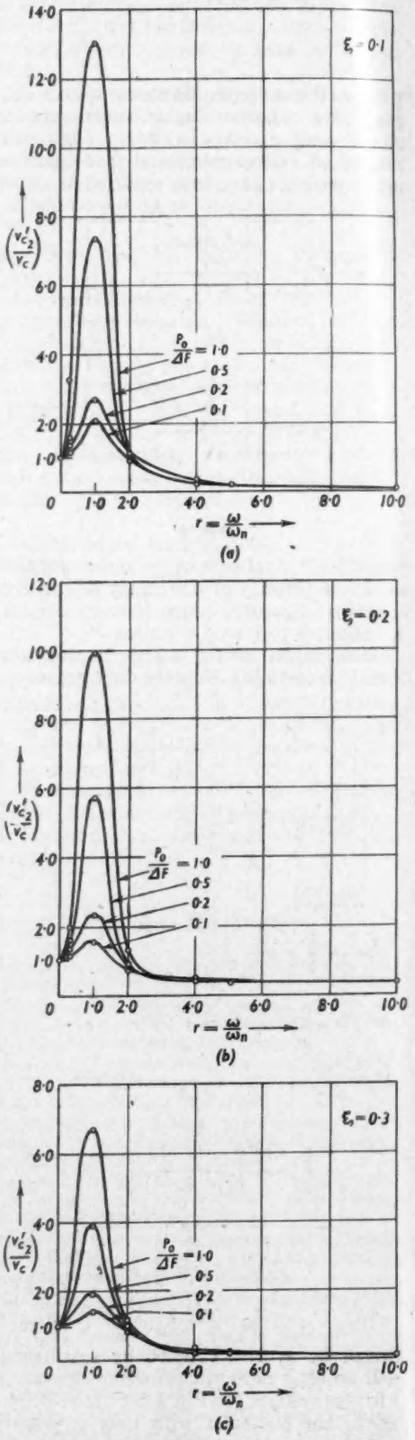

Fig. 5

obtained from the electric analogue computer and also from calculations[4] for critical velocity with the sliding mass under the influence of alternating force for the case with the system driven at steady velocity, the damping ratio of the system being taken at $\xi=0\cdot1$, while in Table III some more results obtained from the computer for $\xi=0\cdot2$ and $0\cdot3$ are included. These results are plotted in Figs. 5(*a*), (*b*) and (*c*) in terms of non-dimensional parameters, such as (V'_{cr}/V_c) the ratio of critical velocity under forced vibration to that under free condition, against ω/ω_n, the ratio of forcing to natural frequency, for different values of damping ratio and those of the parameter $(P_0/\Delta F)$.

The general trend of the curves so obtained reveals that the critical velocity is greatly increased under resonance, while at high-frequency ratios (>5), critical velocity is greatly reduced and at very high-frequency ratios (>10) the stick-slip effect may be completely eliminated. It is also clear that the influence of damping is to decrease the values of critical velocity at resonance. It may be concluded from the foregoing that, in general, the conditions of resonance enhance the stick-slip effect, while high-frequency forced vibration may be employed with advantage to reduce the same effects.

ACKNOWLEDGMENT

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Distribution of Industry

At present a great deal of attention is focused upon the movement of industry to the development areas and to areas with a high rate of unemployment. At the same time, the problem of industrial congestion, particularly in London, remains. This article discusses some of the schemes devised to deal with these matters.

SINCE the beginning of the year, the Board of Trade has been taking various steps to ensure that industry is informed about the financial assistance that can be made available to firms willing to set up, or expand, in areas of the country where there is a high rate of local unemployment. In January, for example, the Parliamentary Secretary to the Board of Trade, Mr. John Rodgers, wrote to the managing directors of about 60,000 firms throughout this country explaining the facilities which the Government provides. These facilities come within the scope of the Distribution of Industry (Industrial Finance) Act, 1958. The main purpose of the Act is to provide more work in those areas of the country where a high rate of unemployment would otherwise be likely to continue and to ensure that no sound project is held up in such areas simply because the money needed for it cannot be found.

Firms which are prepared to move to or extend in one of these unemployment areas may apply for a grant or a loan. The proposals are considered by a Development Areas Treasury Advisory Committee. For a start, any firm which applies must show, of course, that it is a sound concern, that its project is likely to succeed if financial assistance is forthcoming and that it cannot get the necessary facilities from the banks or other sources. These are obvious safeguards as public money is involved. The most recent information as to the progress of the D.A.T.A.C. loan scheme, as it has come to be known, was given in Parliament on March 17. The Parliamentary Secretary to the Board of Trade said then that, since January 1, six applications had been received for Government financed factories or extensions in those parts of the development areas which had high and persistent unemployment; five of those applications had been approved and one was still being considered. The Parliamentary Secretary added that, in these cases, the average time between the receipt of the application and approval had been "within two weeks," though the interval could vary widely with the nature and circumstances of each case. The Parliamentary Secretary said also that, since the beginning of the year, fifty-one applications had been made for assistance under the Distribution of Industry (Industrial Finance) Act, 1958. Of these, three had been approved, three had been refused and the remaining forty-five were still being examined. It was explained that, in the period reviewed, no applications for assistance for "places of rural unemployment" had been forthcoming.

Another way in which the Government is trying to encourage the distribution of industry is by the operation of "industrial development certificates." For some years now these certificates have been refused for firms wishing to expand in the London area, whenever it is considered that they can go elsewhere without undue loss of efficiency. This policy extends also to other parts of the country which are industrially congested and have a low level of unemployment. The official view is that this is a policy which is bound to react to the benefit of those parts of the country where unemployment tends to be high. There are, of course, examples of firms deciding to do nothing if they are not allowed to expand in London. On the other hand, it is felt, the majority of firms faced with a situation of the kind would look for an alternative site and the attraction of a D.A.T.A.C. loan might well be the deciding factor in selecting a location for a new works. But the Board of Trade does not overlook the fact that, in a free economy, industry cannot be directed to particular places any more than can labour. At the same time, it is evidently expected that applications for assistance towards the establishment and expansion of factories in the development areas are likely to increase. In the Civil Estimates (Class VI) for the year 1959–60 the amount required is put at £3,607,500, an increase of £1,373,000 over the amount expended during the financial year which has just ended. In addition, the sum of £7,500,000 is the estimated requirement for "services in development areas" under the Distribution of Industry Acts. This is an increase of £4,734,940 on the total expended last year under this heading.

These schemes, initiated primarily by the Distribution of Industry Acts, are aimed at taking work to places where there are people unemployed and where the prospect of employment, without the introduction of new industry, is not particularly good. There are other schemes which have been designed with the sole idea of relieving the industrial

The firm which occupied this elderly factory building in North London has now moved to Bletchley under the L.C.C. Town Development Scheme

New factory at Bletchley erected under the L.C.C. Town Development Scheme

congestion which has grown over the years within and around many cities and "conurbations" in this land. Foremost among these is the development of the new towns, all of which make special provision to accommodate light and medium industry and provide housing for the people employed by the factories and other organisations which move to them. More recently, however, other efforts have been inaugurated to encourage industry to move away from overcrowded cities and towns. For the most part they are the outcome of the Town Development Act which was passed in 1952.

The L.C.C. and Town Development

The London County Council is one authority which, since the war, has given a great deal of attention to the prevention of industrial congestion within—and, indeed, outside—its statutory boundaries. It may be recalled that, during the second world war, there were published at least two plans of particular importance concerning the future development of London. Both of them inevitably dealt in some detail with the future of London's industries. The first of these documents, *The County of London Plan*, was prepared for the London County Council by Mr. J. H. Forshaw and Sir Patrick Abercrombie, and was published in 1943. This report noted that, in the inter-war years, the outward move of factories from inner London had steadily become more pronounced. But it was also noted that suitable sites were not always easy to find with the result that great concentrations of factories began "to spring up in the relatively few areas where industry could be satisfactorily accommodated." The authors of the report went on to suggest that those pre-war tendencies would again assert themselves and that a continuous and possibly increasing outward movement of factories to the nearest vacant land or suitable premises outside the County of London would set in. It was pointed out that, if not properly controlled, this kind of movement would obviously induce the development of further residential areas and necessitate the extension of transport facilities, the whole operation "resulting in an ever-extending sprawl of the metropolis." The second document, which appeared towards the end of 1944, was entitled *The Greater London Plan*. This, too, was the work of Sir Patrick Abercrombie. The proposals set out in this report were aimed at discouraging the further growth of industry and settlement of population within the London region and at providing for their better distribution and grouping. In the plan it was estimated that approximately 30 per cent of Greater London's factory growth between the wars was accounted for by the decentralisation of industry from congested sites in inner London.

The proposals set out in both these "plans" were carefully studied by a committee representative of the Ministry of Town and Country Planning and other Government departments. Soon after the war it became the declared policy of the Government that the overall growth of London's industry and housing should be restrained and that a planned programme of decentralisation to the outer areas should replace the uncontrolled sprawl of the inter-war years. Reference has already been made to the New Towns Act, which authorised the establishment, under the direction of Development Corporations, of completely new and self-contained towns in suitable places throughout the country. The intention was that the people who went to live in these new towns should find their employment in the industries set up in them. It was not intended that they should become dormitory towns. In the main, that objective is being achieved and, generally, the building of factories, offices and shops has kept in step with the house building programme. Within easy reach of London, there are now eight new towns in the counties of Sussex, Essex, Hertfordshire and Berkshire. Originally, the idea was that these new towns should accommodate people and industry from various hitherto overcrowded London boroughs. As the towns have developed, however, this idea has not been rigidly followed, although the majority of the people and industrial establishments settling down in them have moved from the London area.

In addition to encouraging movement under the provisions of the New Towns Act, however, the London County Council has for some time now been taking other steps to prevent a repetition of the pre-war overcrowding within its area. Since the war, it has acquired land for the development of fourteen "out-county" residential estates in the home counties and on the fringe of Greater London. But these developments have been for the accommodation of people rather than industry. More recently, another scheme has been put into operation as a result of the Town Development Act which was passed in 1952 "to encourage town development in country districts for the relief of congestion or over-population elsewhere." So far as London is concerned, the L.C.C. seeks the co-operation of the local authorities of country towns which are anxious to extend their industries. Some of the towns selected are places where there has been little industrial development or where traditional crafts have virtually died out. Under the Town Development Act assistance is made available to the local authority towards the building of factories and houses for the people who work in them. Factory sites may be purchased by those who wish to build their own establishments or, in suitable cases, the local authority will build and lease factories at economic rents, the minimum period usually being thirty years. Two methods are employed in the prosecution of this scheme. They are known as "nomination" and "agency." The "nomination" projects are those which are undertaken by the local authority itself and the "agency" projects are those in which housing development and industrial site works are undertaken by the L.C.C. as agents of the local authority, subject to arrangements for repayment of capital expenditure as the development comes into use.

These town development schemes are already operating at Swindon, Wilts; Bletchley, Bucks; Haverhill and Bury St. Edmunds, Suffolk; Huntingdon; Thetford, Norfolk, and Edenbridge, Kent, and schemes have been agreed in principle with other towns, including Letchworth, Luton, Aylesbury and Basingstoke. Progress has been more rapid in the first two of these than in some of the others. At Swindon, for example, in the last five years or so, 1207 families from the County of London have been housed and three firms from the County of London and three more from Greater London have become established there. At Bletchley, four firms from the County of London and six from Greater London are established in new factories and about 250 families have moved out from London. Recently we visited Bletchley and saw a number of the new factories which have been occupied by engineering firms which have moved from London. One of the accompanying illustrations shows the crowded interior of an establishment in North London in which an engineering firm was operating prior to moving its business to a new factory at Bletchley, the exterior of which is shown in the other illustration. Progress in the task of moving industry from London is not at present spectacular, but it is continuing. Last autumn the L.C.C. staged an instructive exhibition at Charing Cross Underground Station which demonstrated the advantages of this "out county" development. It has also established at the County Hall, Westminster Bridge Road, S.E.1, an industrial centre to provide full information about the scheme.

Stork Diesel Engine.—On February 24, a paper entitled "The Stork Marine Diesel Engine" was presented by Ir. A. Hootsen and E. A. van der Molen before the Institution of Engineers and Shipbuilders in Scotland. The paper describes and illustrates a single-acting, two-stroke engine, with uniflow scavenging and turbo-charging; there are three engine sizes having bore and stroke and output per cylinder as follows: small engine, 540mm by 1150mm and 500 b.h.p.; medium engine, 630mm by 1350mm and 800 b.h.p., and large engine, 750mm by 1500/1600mm and 1200 to 1300 b.h.p. Details of the engine frame and working parts are given, together with particulars of the oil fuel system and arrangement of the turbo-blowers. Diagrams give air density and also the performance and heat balance of a HOTLo 75/160 engine. Experience with the first production engine is recorded; there are a description and graphs illustrating the development of the unit and a note upon a test engine of 850mm bore by 1700mm stroke, with an output of 1660 b.h.p. per cylinder.

Electrogyro Traction

A two-axle shunting locomotive operating on the Electrogyro principle, in which energy imparted to a flywheel while the locomotive is stationary is used to drive a generator for traction, was ordered by the National Coal Board in 1953. The locomotive was described briefly in our December 27, 1957, issue, and was the subject of a paper presented to the Institution of Locomotive Engineers on March 18 last by T. E. Green, M.I.Mech.E., M.I.E.E., M.I.Min.E., and J. K. Gessler, B.Sc. (Leeds), A.M.I.Mech.E., A.M.I.E.E.† Abstracts from the paper are given below.*

WHEN the development bearing the name "Electrogyro" first came to notice, one factor appeared to be of paramount importance, viz. that it had a cycle of operation which corresponded very closely to the haulage cycle in a large number of mines. This consists of a run hauling a train of empty cars taking from fifteen to twenty minutes, followed by some minutes of waiting and shunting, then the return run with a train of full cars, also taking fifteen to thirty minutes, and again a few minutes shunting and waiting time. The Electrogyro equipment, which provides useful energy for

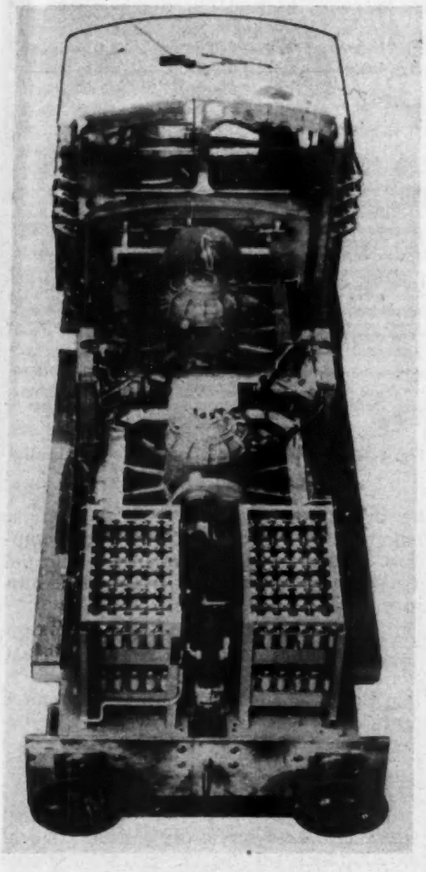


Fig. 1—Equipment under bonnet, showing the two Electrogyros and, in foreground, the two banks of condensers

twenty to thirty minutes, and which energy can be replaced in about two minutes, corresponds very closely with this cycle and suggested considerable possibilities. It was therefore decided that a prototype unit should be built for trials in this country in order that these claims could be investigated in detail. Whilst the ultimate interest was the application of the Electrogyro equipment to underground haulage problems, it was considered that the first trial unit should be designed for surface operation.

It was proposed, therefore, that this first unit should be a two-axle shunting locomotive of about 30 tons weight, a size found to be adequate for a wide variety of duties in colliery yards all over the country. On the recommendation of Oerlikon, Ltd., the inventor and manufacturer of the Electrogyro equipment, the mechanical structure was built in this country and the Swiss equipment shipped here for erection thereon. The contract for the Electrogyros and associated electric equipment was placed with Oerlikon, Ltd., Zurich, and that for the mechanical parts with Thos. Hill (Rotherham), Ltd., the sole concessionnaire of Sentinel (Shrewsbury), Ltd.

The shunting locomotive for the National Coal Board, ordered in 1953, marked a considerable advance as the first motive power unit to be equipped with two Electrogyros working in parallel. Its designed weight and duty also exceeded those of any of the earlier versions.

Theory and Design Parameters

If static capacitors of suitable value are connected in parallel with an externally driven induction machine, the residual magnetism of the latter induces a small alternating voltage which causes a magnetising current to flow. The resulting increase in the flux increases the voltage which builds up in a manner analogous to that of a d.c. shunt machine.

On load, the induction alternator has a slip which increases to 5 or 6 per cent at full load. An inherent characteristic of this type of machine is that the output current leads the voltage vectorially. The load, however (the squirrel cage traction motor), absorbs a lagging current. It is therefore necessary to connect capacitance of a value which is suitable for the particular load and alternator output frequency. The value of the capacitance is of major importance: the alternator will not excite if the capacity is too low, but may produce dangerous overvoltages if it is too high. As the gyro speed falls, more capacity is required for excitation. Increasing load also requires additional capacity in circuit.

This principle of energy transformation is combined with the storage of kinetic energy in a flywheel to form the Electrogyro. A squirrel cage motor is mounted on the flywheel shaft and the traction motors are also squirrel cage motors. This arrangement has the advantage of utilising the simplest form of electric machine without sliprings or commutators, but involves new control problems.

To avoid the use of frequency changers for charging, the electrical part of the Electrogyro is designed for 50 c/s supply in the form of a two-pole three-phase a.c. machine. The stored energy at 3000 r.p.m. is 9kWh, of which about 6kWh are available during operation. Principal dimensions and data of the locomotive are given below, and the internal arrangement is seen in Fig. 1.

Locomotive:	
Gauge	4ft 8½in
Wheel arrangement	0-4-0
Wheel diameter	42in
Length over headstocks	21ft
Length over buffers	23ft 7½in
Maximum width	8ft 6½in
Rigid wheelbase	6ft
Minimum curve radius	80ft
Weight in working order	34 tons
Maximum safe speed	15 m.p.h.
Electrogyros:	
Number	Two
Charging frequency	50 c/s
Working frequency	49–30 c/s
Diameter of flywheel	1622mm (say, 63·9in)
Weight of flywheel	1·56 tons
Total weight of each Electrogyro, including mounting	2·96 tons
Stored energy of each Electrogyro at 3000 r.p.m.	9kWh (=24 × 10^6 ft/lb)
Internal cooling	Hydrogen at approx. 9·5 lb/in² abs. at working temperature
External cooling	Water
Traction motors:	
Number	Two
Type	Three-phase squirrel cage induction motor
Number of poles	4, 6, 8, 12
Continuous rating	25kW at 550V, 50 c/s
Reduction gear	Double reduction, bevel and spur, overall ratio 14·7/1
Rotor cooling	Air
Stator cooling	Water

Each axle is carried in Timken roller bearings and driven by a traction motor, axially disposed, through double reduction gears. The gearcases contain the axle bearings, the motor nose being suspended by a "Silentbloc" arrangement. The traction motors are forced ventilated, but the stator is also water cooled. The Electrogyro units, being the heaviest items of the equipment, are mounted directly over the axle centres. The front section of the machine compartment accommodates two banks of condensers, which are an essential feature of the inductor-alternator excitation system.

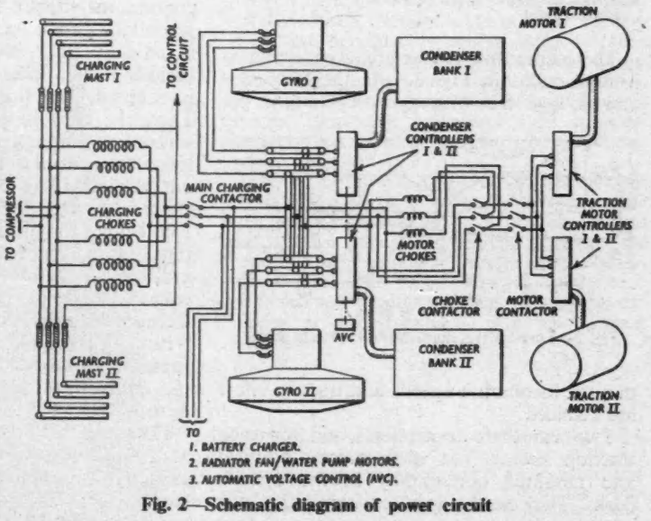


Fig. 2—Schematic diagram of power circuit

Electrical Equipment

The schematic diagram of the power circuit of the locomotive is shown in Fig. 2.

* Chief Traction Engineer, National Coal Board.
† Traction Engineer, National Coal Board.

Energy is taken from the supply by either of the two mast contacts through charging chokes via the main contactor to busbars and thence to the Electrogyros. The main contactor is only closed during charging.

Two identical mechanically-coupled condenser controllers are separately connected to the busbars. A third connection from the busbars leads through a set of choke coils to the two motor controllers. These chokes assist transition during notching; they are short-circuited when the traction motor runs at near synchronous speed.

The two traction motor controllers are again identical and mechanically coupled. Four forward and four reverse speeds can be selected by pole-changing.

The Electrogyro, which is both energy store and energy converter, consists of a flywheel and a three-phase squirrel cage motor built in one unit. The hollow vertical shaft carries the squirrel cage rotor above the flywheel. The airtight casing is filled with hydrogen at about two-thirds atmospheric pressure, which serves both to reduce windage and to transmit heat from the hollow rotor bars to the water-cooled stator.

The rotating mass is suspended from one angular contact ball bearing, which permits limited inclination of the axis. When the flywheel rises due to gyroscopic forces, radial restraint is maintained by the guide bearings above the suspension bearing. Both this and the lower guide bearings are normal ball bearings. The speed of each gyro is indicated on an instrument on the driver's desk, fed by a small alternator of which the permanent magnets are secured to the top of the gyro shaft.

The two traction motors are single pole-change squirrel cage motors with double reduction gears, resulting in four locomotive speeds which are determined by the prevailing gyro revolutions per minute. With fully-charged gyros the maximum speeds are :

Controller position No....	1	2	3	4
Motor connection (poles)	12	8	6	4
Synchronous motor speed (r.p.m.) (at 50 c/s)	500	750	1000	1500
Maximum locomotive speed (m.p.h.) (approximately)	4	6	8	12

The locomotive characteristic as designed is reproduced in Fig. 3. As the frequency and voltage fall with gyro revolutions per

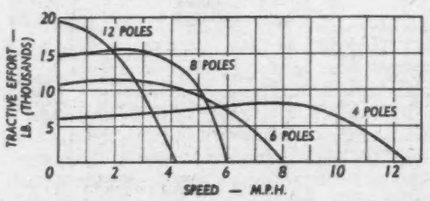


Fig. 3—Locomotive characteristic (design curve)

minute, locomotive speeds and tractive effort are reduced.

Two camshaft controllers, one for each traction motor, are mechanically coupled and mounted horizontally in the driver's desk. They can be operated from either side of the cab, giving four forward and four reverse speeds with a central "off" position. Chokes are automatically inserted between gyros and traction motors during notching. Their function is to assist smooth build-up of gyro excitation and to reduce torque peaks.

Each gyro is connected to a bank of condensers which supply the reactive current necessary for the excitation of the induction generators when running and for power factor improvement when charging. The condensers [delta-connected] are mounted in eighteen groups, arranged in two banks. Each group consists of twelve 43μF condensers. Discharge resistances are fitted to each group. The two mechanically-coupled condenser controllers are of camshaft type. They are operated by handwheels on either side of the desk, the movement being transmitted through a sprocket and chain. When the automatic voltage control comes into operation, hydraulic pistons (later replaced by pneumatic pistons) reduce the excitation step-by-step until the voltage has reached a safe value.

Automatic voltage control is a most important part of the control equipment which permits the driver to connect sufficient capacity to ensure excitation of the Electrogyro, but holds the generated voltage to safe limits by automatically reducing the capacity in circuit when necessary. For heavy starts, the voltage is permitted to increase with the current taken by the traction motors.

This "compensation" is achieved by a circuit in which the primary of a control transformer is connected across the gyro phases. The open secondary is connected to rectifiers and a second transformer with d.c. premagnetisation. The latter is biased in proportion to the load current. The third harmonic output of the open secondary of the control transformer governs the process which reduces the controller position until the gyro output reaches a safe voltage. Heavy traction motor currents increase the premagnetisation and therefore the impedance which delays the initial operation of the voltage control. Consequently, a higher gyro voltage is generated which increases traction motor torque.

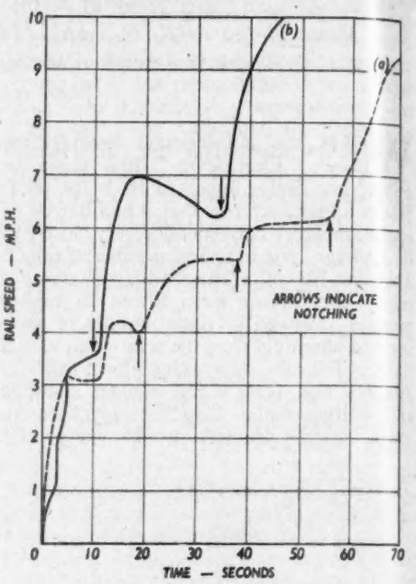
Stationary Charging Equipment

The incoming 2750V, 50 c/s, three-phase supply is transformed to 550V for the charging stations situated at convenient points at the side of the track and to 220V for the charging station in the locomotive shed. The transformers are rated 300kVA continuously/600kVA intermittently. The secondary circuit includes 700A h.r.c. fuses in advance of a 600A, three-phase, circuit breaker, which can only close when a 24V pilot circuit from the locomotive is energised. Thus, the bare copper contact bars on the stationary charging mast are dead until the locomotive at the charging station swings out its mast. The lowest contact rail on the stationary mast for the 24V circuit is set 1½in behind the plane of contact of the other rails. Thus, the three upper power contacts must close before the fourth, the pilot contact, comes in. Similarly, as soon as the locomotive masts begin to return to the "running position," the pilot circuit is interrupted first, the station contactor opens and the contact bars of the charging station are dead.

[The paper compares methods of charging at 200V, one way (*a*) being to vary the capacity for approximately constant mains current, and the other (*b*) to vary it for minimum power. Energy consumption is of the order of 40kWh up to 2000 r.p.m. and 50kWh up to 2900 r.p.m. by method (*a*) and some 15 per cent less by method (*b*). Times of charge from 0 to 2000 r.p.m. are thirty-five minutes (*a*) and thirty minutes (*b*); and from 0–2900 r.p.m., forty-seven minutes (*a*) and forty-four minutes (*b*). Curves are reproduced of a typical charge at a 550V station from about 1800 r.p.m. to near synchronous speed, the times in this case being between 140 and 150 seconds. This is the starting speed for a recharge under normal operating conditions.]

Operation

Fig. 4 compares two methods of acceleration from Hartley charging station and shows that the process can be considerably speeded



	Units	(*a*)	(*b*)
Curve reference	—	16/3	18/9
Test No....	—		
Motor controller notches used...	—	1.2.3.4	1.3.4
Maximum speed reached	m.p.h.	9·3	over 10*
Time to reach maximum speed...	sec	70	46
Approximate distance travelled...	ft	550	400
Initial gyro speed...	r.p.m.	2850	2950
Gyro speed at max. train speed	r.p.m.	2650	2750
Gyro energy used	kWh	2·2	2·4
Total energy to travel 550ft from standstill	kWh	2·2	2·7

* Curve (*b*) is incomplete as the driving chain of the speedometer broke at forty-six seconds, and the test could not be repeated.

Fig. 4—Comparison of two methods of acceleration

up by omitting the eight-pole connection, but at the cost of increased energy consumption. Curve (*b*) may be compared with the usual method shown in Curve (*a*) as shown in the accompanying table.

If the train is accelerated by notch-to-notch progression a stepped form of acceleration is obtained. The more uniform acceleration produced by starting directly in motor notch 3 has been used for flyshunting.

Driving Technique

The motor controller may be compared with the gear lever of a car and the condenser controller with the accelerator. Release of the motor control lever corresponds roughly to the release of the clutch pedal. After recent modifications the motor pole-change lever has three positions and is spring loaded to return to the central position when released. To start the locomotive, movement of the lever in the direction of travel engages the first (twelve-pole) connection. The condenser control handwheel is simultaneously turned to the right. In one or two seconds the gyro excitation has built up and as the locomotive moves, the automatic voltage control reduces the excitation to a safe value. Release of the motor control lever short circuits the traction motor chokes

which were inserted automatically by operation of the motor controller.

Further acceleration is a repetition of this process. A second movement of the motor lever engages the next notch (i.e. eight poles), while excitation is increased for transition as before. Notching back is a reversal of the procedure. After some experience, the driver moves the handwheel to a known position in order to start a certain load immediately after charging.

As the gyro speed falls, the voltage is reduced and the handwheel must be moved to increase excitation. Similarly, increase in gradient requires more excitation. If the driver neglects to do so, gyro excitation may collapse. A reduction in gradient results in too high a voltage and the automatic voltage control moves the handwheel controller to reduce the capacitance connected.

The manner of acceleration is entirely in the driver's hands. As illustrated by Fig. 4, it is not necessary to go through every motor controller position. Omission of the eight-pole position results in faster acceleration (Curve (*b*)). It was even found possible to start the same load (101 tons trailing) in the six-pole connection at 2600 gyro r.p.m.

In summary, it can be said that the high capital cost will militate against extended use [of the system described] on the surface, and so far no outstanding compensating advantages have been revealed which would balance the high financial charges. Underground the position, at the time of writing, is somewhat different. The diesel and battery units have severe limitations and there does appear to be a good case for further investigation with an underground unit. Negotiations to this end have been initiated.

Automatic Cycle Multi-Tool Production Lathe

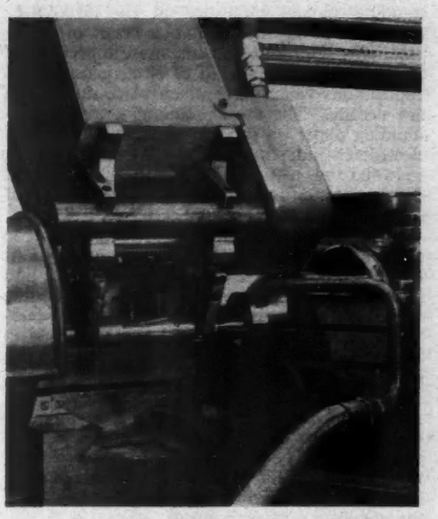
THE "Maximinor" lathes made by Drummond Brothers, Ltd., of Guildford, have been well known in industry for many years, and a recent development of interest in this range of machines is an automatic production lathe incorporating multi-tooling with copy-turning equipment. The machine can also be fitted with automatic handling equipment for components, as shown in the accompanying illustrations.

The basic machine is a standard "Maximinor" lathe which will accept work up to 18in long and will swing 12in diameter over the bed and 7in diameter over the slides. It has a spindle speed range from 500 to 2500 r.p.m., the drive being taken directly through Texropes from a 10 h.p. electric motor mounted at the rear of the headstock. A hydraulically-operated compensating chuck, complete with spring centre, is fitted to the headstock mandrel flange. The hydraulically-operated tailstock contains a built-in revolving spindle.

The rear tool slide on this machine can be used for forming undercuts, shoulders, &c., and it is controlled by flat plate cams within the bed of the machine. The feed rate of this slide is adjustable by pick-off gears in the feed box, and rapid traverse in either direction is provided by a separate electric motor. Engagement feed is also controlled through pick-off gears in the feed box.

The front slide normally fitted to this design of lathe is replaced by a hydro-electric copy-turning attachment. This attachment is mounted at 30 deg. to the axis of the machine and consists of a hydraulic slide carrying the copy-turning tool block, the former plate for copying being mounted on a carrier bar fitted at the front of the machine. The copying unit is electrically controlled within the automatic cycle of the machine so that after the "Start Cycle" button is pressed, the unit feeds in and at the completion of the turning cycle automatically withdraws to the starting position.

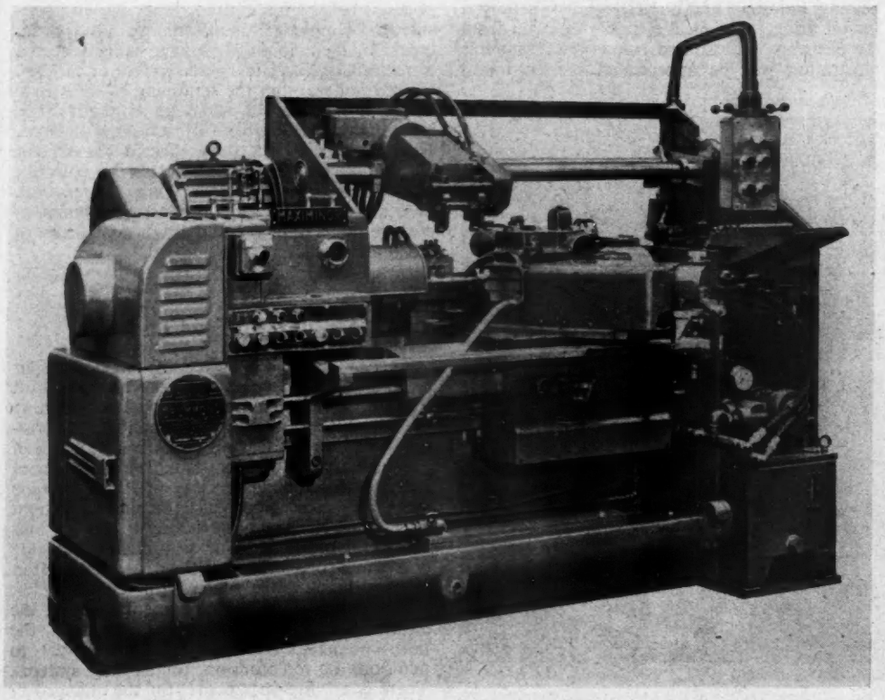
The machine is designed to work on an automatic cycle and the automatic component handling equipment shown in our second illustration consists of a rotatable work holder comprising two sets of spring loaded jaws. One set of these jaws for holding an unmachined component are called the "loading jaws," while the other set for holding a finished component are called the "unloading jaws." The work holder is rotated backwards and forwards through 90 deg. by a double-acting hydraulic cylinder controlled by a solenoid-operated valve. This work holder is mounted on the end of an arm that can be rocked up and down by another double-acting cylinder, and it is so positioned that in the down position either set of spring-loaded jaws are brought on to the machine centre line by rotating the work



Automatic loading equipment with blank about to be inserted between centres as arm grips turned piece

holder. In the "up" position the arm can be traversed clear of the machine tailstock into a position over the loading hopper and unloading chute. The traverse is imparted by a double-acting hydraulic cylinder, through racks and pinions, so that a long travel is obtained with a short-stroke cylinder. When the arm is clear of the tailstock it can be rocked down and it then presents the jaws in a suitable position for the magazine to push a fresh component into the loading jaws and at the same time eject the finished component from the unloading jaws. All the motions, together with the chuck and tailstock, are operated by double-acting hydraulic cylinders controlled by solenoid-operated valves. Limit switches give indication of the completion of every movement and the electrical control ensures that each movement must complete correctly before the subsequent movement may begin.

All the movements of the loading equipment can be operated by switches for setting up, the switches being mounted on a pendant control box, and rotation of the box engages either the "setting" or "automatic" condition. When in "automatic" the equipment will continue to load and unload the machine as long as the hopper is kept supplied with unmachined components.



Automatic production lathe for multi-tool and copy turning, fitted with automatic handling equipment

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TWO MAJOR CONFERENCES ON PLASTICS.—A two-day conference entitled "The Influence of Plastics in Building," and intended mainly for architects and constructional engineers, will be held at the headquarters of the Royal Institute of British Architects on November 19 and 20, 1959. It is being organised by the Plastics Institute, which also plans to hold a two-day conference on "Polymeric Progress" in the William Beveridge Hall of London University on March 30 and 31, 1960. The first day's proceedings will open with a one-hour paper on "New Polymers: New Problems," by Professor H. F. Mark, from the Polytechnic Institute of Brooklyn. The remainder of the first day will be devoted to materials and the second day will be concerned with present and future methods of polymerisation. Contributions will be made by other leading authorities from the United States of America, Germany, Italy and the United Kingdom.

SHORTER REPORTS

New Brit.I.R.E. Premiums

THE council of the British Institution of Radio Engineers has announced that it is to establish four additional premiums for the authors of outstanding papers published in the *Brit.I.R.E. Journal*. It is intended that two of these premiums shall take account more especially of the extensions in the field of electronics and its applications which have taken place during the last decade. The third premium is for an outstanding paper on production techniques in the electronics industry, and the fourth has been endowed by a past chairman of the North Eastern Section to encourage the presentation of papers before that Section.

In addition, the council has decided to increase the value of the Clerk Maxwell Premium. This is the senior premium (instituted in 1946) and is awarded to the author of the outstanding contribution, irrespective of the subject, published in the *Journal* during the year. With effect from 1958, its value will be twenty-five guineas.

Details of the new premiums are as follows :

Charles Babbage Premium : For an outstanding paper on the design or use of electronic computers. The title recognises the pioneer work of Babbage in first formulating the requirements for a calculating machine. The value of the premium is fifteen guineas.

Lord Rutherford Premium : Electronics plays an ever-increasing part in control and instrumentation associated with atomic physics and nuclear engineering. The premium commemorates the fundamental work carried out by Lord Rutherford at the Cavendish Laboratory, Cambridge, and is awarded for an outstanding paper on electronics associated with atomic physics. The value of the premium is fifteen guineas.

Arthur Gay Premium : The importance of efficient methods of production in the electronics industry led to the establishment of this premium for an outstanding paper on production techniques. The late Arthur Gay was a production engineer associated with H. J. Leak (Member) who has endowed the premium. Its value is ten guineas.

Hugh Brennan Premium : This is to be awarded annually to the author of the most outstanding paper read before the North Eastern Section of the institution, and subsequently published in the *Journal*. The value of the premium is fifteen guineas.

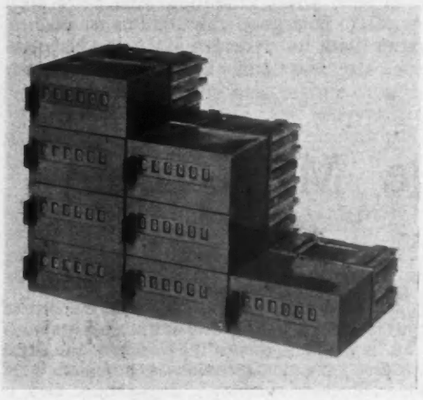
Papers falling under the terms of reference of these four premiums, and published in the *Journal* during 1959, will be automatically considered for the awards. With the introduction of these awards the total number of Brit. I.R.E. premiums awarded annually is now thirteen.

Electromagnetic Counters

FROM the beginning of April, Lancashire Dynamo Electronic Products, Ltd., St. Stephen's House, Victoria Embankment, London, S.W.1, has had sole selling rights in Great Britain for Hengstler " F43 " and " F43M2 " electromagnetic counters. This arrangement has been made with J. Hengstler K.G. in Germany, through the good offices of Brian R. Morris and Co., Ltd., 118, London Road, St. Albans, Herts, its agent in this country, who continues to market here other Hengstler mechanical and slow-speed electromechanical counters.

The " F43 " and " F43M2 " electromagnetic counters are basically similar in design, but the " F43 " has manual reset and the " F43M2 " both manual and electrical reset. They are capable of counting at speeds up to 2400 impulses per minute and both provide six-digit indications. Both types are available in high-speed or low-speed versions and at a number of preferred d.c. operating voltages. Rectifier units for operating the counters at certain preferred a.c. ratings will also be available in the near future.

Each counter plugs into a socket box, to the rear of which the incoming connections are made.



Assembly of counters built up with interlocking socket boxes (at rear)

The illustration shows a number assembled in this way and fitted together to form a block by interlocking the socket boxes, which are pressure die-castings formed with projections on four faces to allow banks of counters to be built up into single structures.

Sectional Combustion Chamber for Small Oil-Fired Boilers

A FREE-STANDING combustion chamber which can be built up from standard sectioned elements has been developed by J. Bartholomew and Son, Ltd., Longton, Stoke-on-Trent, for use in central heating, industrial and domestic boilers arranged for oil firing. A typical chamber built up from the elements is illustrated below, and from this illustration will be appreciated the ease with which a combustion chamber to suit the oil flame can be arranged.

Combustion chamber built up of free-standing sectional elements

The sectional elements are made of a high alumina concrete to withstand the thermal shock conditions imposed by normal on-off oil burner operation. The side and end sections are ported to allow hot convection currents to reach a boiler waterway. The sections are easy to handle, store and install, and in the event of a replacement being needed in a chamber a single section can be removed and replaced without disturbing the remainder of the assembly.

Naval Architects' Annual Dinner

IN proposing the toast of " The Institution of Naval Architects," at the annual dinner of the Institution held on March 24 at Grosvenor House, London, Sir Nicholas Cayzer, Bt., linked the prosperity of shipbuilding with the state of British shipping and drew attention to the fall in our share of world trade from 26·1 per cent in 1939 to 17·2 per cent in 1958. He quoted figures for the tonnage laid up, completed in 1958, and under construction, and regretted the increased volume of shipbuilding, especially that which resulted from considerations of national prestige. World trade, he felt, would increase, but if shipping did not achieve equilibrium the outlook would be gloomy, and for Great Britain to obtain her share would call for economies by both shipowners and shipbuilders. The lack of discipline in the yards, largely stemming from the ease of obtaining orders in conditions of a sellers' market, must be remedied since the shipbuilding industry must be much more highly competitive to attract orders even from British shipowners. The latter, Sir Nicholas emphasised, had to compete in a market which was heavily loaded against them, so that, sentiment apart, to remain in business orders had to be placed as governed by considerations of price and delivery. Thus British shipbuilders, he continued, will be under pressure to produce economic ships at a competitive price and all must realise that no one owes us a living. Viscount Runciman, the president of the Institution, responded and considered the present state of shipping in the world, especially the amount of tonnage being delivered in relation to that laid up due to lack of cargoes. He did not feel that the scrapping of ships over twenty-five years old, although it might help, would solve the problem of achieving balance. How this was, in fact, to be effected was difficult to predict, but the process would be painful ; nevertheless, the president was sure that, eventually, efficient ships produced at minimum cost would be wanted and that was a challenge to naval architects.

Mobile Radio Channels

APPROVAL has been given by the Postmaster General to the recommendations in the Third Report of the Mobile Radio Committee regarding the introduction of equipment capable of operating in the low v.h.f. band on a channel width of 25 kc/s instead of 50 kc/s. Double the number of channels for mobile services will thus become available. The report also includes a revised allocation of channels amongst the various categories of users. The new channel spacing comes into force on June 1 this year. Thereafter, all new land-mobile schemes in the low v.h.f. band will have to use equipment meeting the 25 kc/s specification. With few exceptions, the new equipment standard will also apply to additions or replacements for existing systems. There is a " five-year plan " for the changeover of existing services to 25 kc/s equipment to be completed by June 1, 1964.

Distillery at Kennington

Now nearing completion at Montford Place, Kennington, is a building which has been largely reconstructed for use as a distillery for James Burrough, Ltd. About 75,500 square feet of floor area is provided, of which the still house and the boiler house occupy 17,500 square feet, and the bonded warehouse 29,000 square feet, while 7000 square feet is allocated to offices. The building forms a triangle in plan with the west wing five floors in height being divided into two by a central staircase and having the south end converted into the rectifying premises with the still room on the second and third floors, and blending being carried out on the first floor and dispatch on the ground floor. The north end of the wing has been modified for use as bond and duty paid dispatch on the ground floor, with bonded case storage on first and second floors and offices on the two top floors. Bottling and case storage has been allocated to the north side of the triangle while the south wing, which like the north is of three floors, is used for general storage and bottle washing.

The main problems involving structural alterations were those related to the still house, which was required to house five rectifying stills, some 33ft in height, two smaller stills, pot stills and condensers with gravity feed to blending tanks on the first floor. To accommodate such equipment required the partial removal of the third floor and the complete removal of the fourth and calculations of industrial loading, as related to weight bearing capacity of the walls, indicated that sufficient margin of loading remained provided that the new roof spanned the 48ft between the walls. The roof is constructed of welded tubular steel lattice trusses spaced at 9ft centres and fitted with a framed knee brace at the bearing to stiffen the external walls, which are unbraced for nearly two-thirds of their height. Briggs Bitumetal aluminium decking forms the roof covering and gives a *U* value of about 0·33. Another structural problem was that posed by the need for an open-topped tank of 27,000 gallons capacity, for the storage of condenser cooling water, which had to be sited on the main roof. To meet requirements for steam, central heating the old solid fuel boiler was removed and an oil-fired Babcock and Wilcox "Steambloc" boiler of 10,000 lb of steam per hour capacity was installed complete with an oil fuel storage tank of 3000 gallons capacity, while provision was made for the installation of a second boiler at a later date.

For blending operations there are 4000, 2000 and 1000 gallon Prodor-Glaslined vats fitted with built-in stirrers and also a 20-ton weigh tank. When complete the bottling hall will have one line with an output of 300 dozen bottles per hour and two to handle seventy-five dozen bottles per hour. A British Miller Hydro bottle washer serves the main line and uses 500 lb of steam and 500 gallons of water per hour, while filling is by an "Albro" C.T. 15 head machine. After individual scrutiny the bottles are fed to a Purdy Linomatic body labelling machine and then on to a Metal Closures A.C. Capping Machine. Filled cases are handled by various sets of conveyors to storage and to dispatch. John Dore and Co. are responsible for the stills and piping, the potential output of the twelve units being 10,000 gallons a day. The still capacities range from 150 to 2000 gallons per day, and our illustration shows the still room with the first still, a 2000 gallon capacity unit, and associated condenser installed.

The architects for the project were Messrs. Douglas and J. D. Wood, and the consulting engineers were Messrs. Laithwaite and Bak, and Messrs. Wells and Walchi were the quantity surveyors, while the main contractors are Marshall Andrew and Co., Ltd.

Plant at the National College for Heating, Ventilating, Refrigeration and Fan Engineering

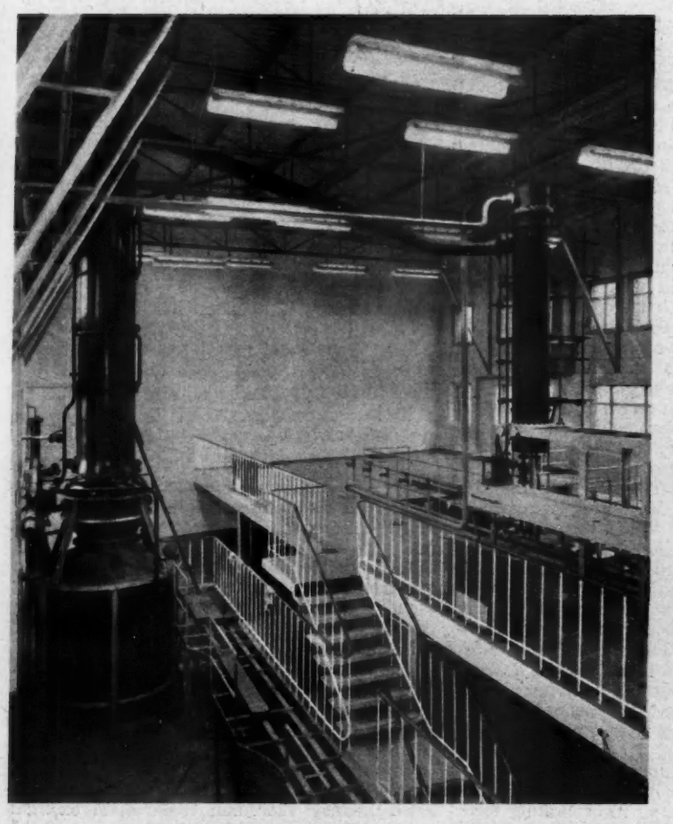
A NEW building for the National College of Heating, Ventilating, Refrigeration and Fan Engineering is to be built in Southwark Bridge Road, London, S.E.1, close to the Borough Polytechnic. The governors of the college have published a brochure which appeals for funds for installing plant in the new building. The principle behind the national colleges of partnership between the industry concerned and the Ministry of Education is explained in the brochure, and a tradition of support from the three industries here involved is commented upon. However, it is pointed out that unless generous support is forthcoming, the college will have a fine new building but little in the way of plant and equipment. The Ministry of Education will pay for the building which will cost over £200,000. The governors of the college want to raise £50,000 for the plant. They have appointed Messrs. J. Roger Preston and Partners as consultants for the mechanical services, which it is planned will be as follows.

It is proposed to install a representative modern heating, ventilating and air conditioning system which can be observed and tested by students under normal working conditions, in addition to the laboratory equipment and machinery which will be used for experimental and research work. The heating plant laboratory will accommodate a number of heat generating appliances which will supply warm water and steam for use throughout the building. These appliances will comprise low-pressure hot water oil-fired boilers, oil-fired steam boiler, gas-fired steam boiler, heat exchange equipment, and electric thermal storage vessel to be used during off-peak tariff periods. The numerous circuits which will be necessary to serve the heating systems will have automatic controls and pumps of various kinds. Heating for the building will include low-temperature embedded floor panels, low-pressure hot water heating, suspended ceiling heating, electric heating, and a small system to demonstrate the small bore heating system. All the laboratories on the lower levels of the building will have mechanical ventilation employing ducts conveying air at conventional velocities, the inlet air being heated in winter. An exhaust system for the rapid removal of fumes is to be provided for the refrigeration laboratory and the lecture theatre will be equipped with its own air conditioning system. The two upper floors of the building are to be air conditioned. On one level the air conditioning system will incorporate a dual duct distribution system, the ducts for which will convey air at high velocity. On the other air will be conditioned by diverse air handling units, to which a supply of chilled water will be available. Self-contained air conditioning units will also be demonstrated. Some of the refrigeration and air conditioning machinery will be accommodated on the roof of the building, together with a water-cooling tower and evaporative condenser. All systems are to be fully instrumented to enable the student to gain a full appreciation of their functioning.

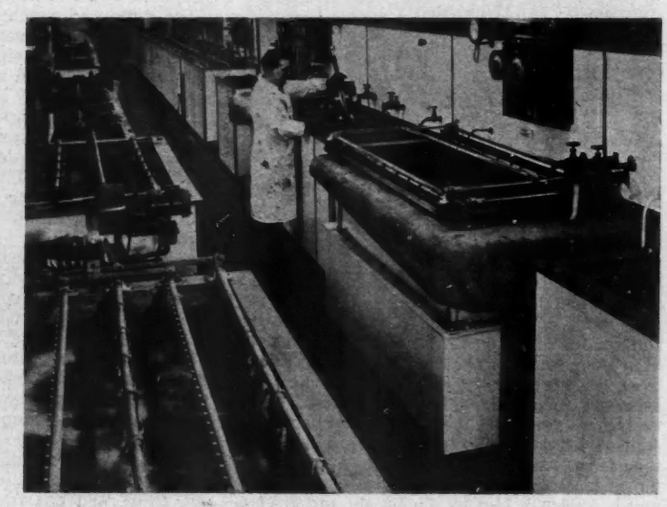
Electrodeposition Research Centre

A NEW technical centre for research and development in electrodeposition has been opened by Canning and Co., Ltd., at Great Hampton Street, Birmingham, 18, where the analytical, metallurgical, service and lacquer laboratories are now assembled, together with a plating department for demonstration and research purposes.

The main plating shop is on the ground floor with the tanks arranged in two parallel rows; barrel plating equipment with separate rectifier control is adjacent; also the polishing room and barrel finishing sections. Fume extraction has been provided by exhaust ducting from the lip



Still house showing first rectifying still with its condenser in position



The chrome line at the Electrodeposition Research Centre, showing two plating tanks with exhaust ducting for fume extraction

of the tanks (see illustration), the ducting being carried downward and connected to main trunking under the flooring of the shop. The tanks and controls are cased in plastics, and the tank tops are at a common level.

The main laboratories are on the first floor, together with the executive offices and service chemists' department. Here, also, entirely new equipment has been provided and an instrument room has been equipped with the latest research apparatus. Separate laboratories have been provided for lacquer development. On the top floor is a lecture theatre seating over seventy and equipped with a 16mm projector and sound equipment.

A photographic department, with air conditioning, has been installed in the basement for processing photomicrographs, lantern slides and general work.

New Equipment for Electronics and Automation

A RANGE of new components suitable for incorporation in electronic devices and servo-mechanisms, some of which have been used already in guided missile tests, was exhibited in London recently by the Woden Transformer Company, Ltd., Moxley Road, Bilston, Staffs. One of the devices demonstrated was a new and compact patchboard system, the Woden-T.S.P., in which the boards have removable plug panels so that a number of combinations of connections can be set up and stored. The standard board measures 7in by 4in and has 334 sockets at ¼in pitch. The barrel design of plug is easy to insert and remove, but cannot be pushed out accidentally when the panel is placed in position over the contacts, which are self-aligning and spring-loaded, the pressure on the nose of each plug serving to lock it in place. To bring any combination into use, the appropriate front panel, with the plugs already in the required positions, is inserted into a hinged holder which is then closed against the back plate and locked by two spring catches. A typical application would be for machine tool programming, the removable panels being preset for various sequences of machining operations. Plug positions for producing a particular part could be coded so that they could readily be reproduced when required.

Patchboard, showing contacts on back plate and plug panel positioned in hinged frame

A series of torque motors was also shown, suitable for direct operation of hydraulic valves in servo systems in response to control current from an electronic or magnetic amplifier. A specimen exhibited had been recovered after being fired in a "Black Knight" rocket and was still fully operational. Four types are available, the three smaller units having approximate dimensions of 1½in by 2½in by 1$\frac{13}{16}$in. A larger motor measures 4¾in by 4in by 4in and gives a linear torque output of 96 oz per inch at 120mA max. Feedback windings or potentiometers can be incorporated in all models. Angular movements of the shaft are 7 deg. or 4 deg. either side of natural centre. The devices are, in fact, electro-mechanical transducers producing an angular deflection proportional to the applied current.

The other items exhibited were Woden-T.S.P. wire contact plug-in relays, introduced to meet the demand for a high-speed, multi-pole relay for computer and general engineering control applications. The basic unit is a four-pole relay with readily interchangeable twin-wire contacts. Six-pole relays are also available. Present operating and release times are down to 3 milliseconds but will be reduced to 2 milliseconds in a forthcoming pattern.

Communications for U.S.A.F. British Bases

A MOBILE microwave telephone and telegraph communication system is to be supplied by British manufacturers for linking many of the United States Air Force bases in the United Kingdom. Each mobile station will be self-contained, with its own power supply, enabling units to be deployed individually or collectively. A contract totalling some 3,500,000 dollars for these installations was placed last week by the United States Government with Marconi's Wireless Telegraph Company, Ltd., Chelmsford, Essex, with which is associated the Automatic Telephone and Electric Company, Ltd., Strowger House, Arundel Street, London, W.C.2, the complete system having been planned by these two firms.

The radio equipment to be employed is the new Marconi type HM510 series, which operates in the 4000 Mc/s band, and is capable of carrying 240 telephony channels. An English Electric Valve Company travelling-wave tube is used in the final stage of the transmitter, giving a power output of 2W. The receiver employs a low-noise crystal mixer feeding a low noise i.f. amplifier which, in turn, drives a demodulator. The i.f. amplifier and "modem" circuits employ printed circuit techniques. A comprehensive supervisory and order wire system will also be provided. The system is designed to be flexible and channels can be inserted or extracted at the repeater stations without difficulty.

Telephone carrier equipment will be provided by the Automatic Telephone and Electric Company, Ltd., and will function in the frequency band 60 kc/s to 552 kc/s. Where the system is not yet fully loaded with channels, facilities are provided for easy expansion. The carrier equipment uses conventional 4 kc/s channel spacing and conforms to C.C.I.F. standards. A modern assembly method known as U.C.P. (unit construction practice) is used throughout. The telegraph channelling equipment will be provided by the Telephone Manufacturing Company, Ltd., which is associated with the Automatic Telephone and Electric Company, Ltd.

The radio and channelling equipment will be accommodated in semi-trailer air-conditioned vehicles. Mobile units containing repeater equipment will be used where the distance to be covered is considerably in excess of line-of-sight.

Lightweight radio tower equipment will be supplied by Access Equipment, Ltd., Maylands Avenue, Hemel Hempstead. This will comprise one 204ft and three 120ft "Zip-Up" stairway type masts; and one 200ft and twenty-four 130ft triangular masts. While suited for permanent installations, these light aluminium towers can be dismantled, transported and reassembled on new locations quickly and with minimum of erection equipment and personnel. A 204ft "Zip-Up" stairway type tower, when dismantled, can be carried in one 2-ton truck. It is stated that erection and guying of a 204ft tower can be completed in only four hours by a team of eight men, who work enclosed within the structure, with ample platform areas at all levels.

These towers are built up with a series of interchangeable folding sections which, when opened out, form rigid box frames incorporating their own stairway. The frames are automatically held square and secure by the diagonal stairway and braces, which have snap-on locking hooks. Successive sections are interlocked one on top of the other by spigots registering in the tops and bottoms of the vertical corner tubes. When the 18ft level has been reached, the pre-assembled sections are hoisted up by a davit which is hooked to the top of the tower and moved up progressively as each section is added. The whole of this operation is carried out without the use of nuts, bolts, tools or loose parts.

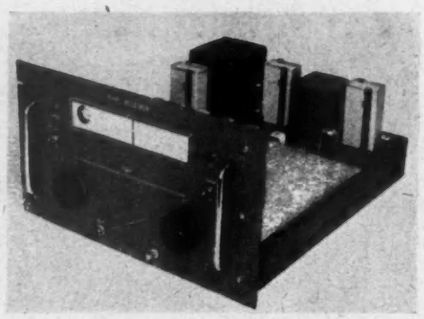
The triangular masts are also made up of interlocking sections, but in this case, owing to the narrowness of the towers, erection is carried out from outside. A davit is used on each section as before.

Twenty-five diesel-alternator sets for stand-by power supplies will be provided by Austinlite, Ltd., Crawley, Sussex, a member-firm of Stone-Platt Industries, Ltd. These 30kVA sets will be in duplicate to form a secondary and tertiary reserve of power in case of mains failure and will incorporate the Austinlite "no-break" principle of flywheel energy storage to bridge the gap between the mains failing and the diesel engine taking over. The sets will be mounted in mobile trailers, together with automatic control switchgear cubicles.

Other firms associated with Marconi's Wireless Telegraph Company, Ltd., in this project are Hands (Letchworth), Ltd. (vehicle chassis), Bonallack and Sons, Ltd. (vehicle bodywork), and Thermocontrol Inst. Company, Ltd. (air-conditioning).

Receiver for 420/470 Mc/s Band

A U.H.F. receiver for the range 420/470 Mc/s is available in several versions, arranged to meet specialised requirements, from Sir W. G. Armstrong Whitworth Aircraft, Ltd., Baginton Aerodrome, near Coventry. We illustrate the receiver in its "Comel 7(b)" form, in which the panel is 19in wide and a power unit is incorporated. Signals are fed from the coaxial aerial connector to the cathode of a grounded-grid amplifier, the anode circuit of which is tuned by the right-hand control, labelled "Tune R.F." The output is applied to a grounded-grid mixer stage, with separate local oscillator which is tuned by the "Tune L.O." control to give an i.f. of 45 Mc/s in the mixer anode circuit.



Low-noise u.h.f. receiver and power pack

The i.f. amplifier is preceded by a low-noise input stage and consists of three stages having stagger-tuned circuits set up to provide a steep-sided, flat-top response. Part of the output is further amplified for application to an automatic gain control diode feeding back to the first of the three i.f. amplifiers. A tuning indicator is also connected to the A.G.C. line. The i.f. signal is detected by a crystal detector, the output from which is fed to a cathode-follower stage and appears at the "output" plug on the front panel. Total weight of the receiver, including power pack, is approximately 42 lb.

An alternative version of the receiver is supplied in an 8in by 8in by 15in case suitable for mounting in aircraft standard racking. This model weighs approximately 12 lb and requires an external stabilised power supply. In both types the bandwidth can be adjusted to 6 Mc/s if required.

Industrial and Labour Notes

British Steel

At the annual meeting of the British Iron and Steel Federation, which was held in London on March 24, the president, Mr. Lewis Chapman, commented on the fact that throughout last year the export market for steel became increasingly competitive. It was, however, satisfactory to note, he said, that, although total exports were lower by 400,000 tons than the record figure for 1957, British steel makers maintained their share of the world export market in 1958.

Mr. Chapman went on to say that, with the steel industry working at less than 75 per cent of its capacity by the end of last year, some unemployment was regrettably unavoidable. Nevertheless, by the diligent search for orders at home and abroad, every effort had been made to maintain the level of employment in steel as high as possible. Government measures already taken had stimulated mainly the consumer goods industries. If, he added, a more favourable climate was created by Government measures to stimulate investment, the steel industry believed that demand would become firmer from about the middle of this year. By then, Mr. Chapman said, the reduction in consumers' stocks should be nearly complete and should help towards a steady recovery in demand. While in the longer term, he continued, demand at home and abroad was expected to rise, competition for orders would still be acute as trade barriers were lowered and countries which formerly imported all their requirements installed their own steel plants, a development which was proceeding at a rather rapid rate.

Mr. Chapman then commented on the "threat" by the Labour Party to re-nationalise the iron and steel industry if it should be returned to power. Under this heading he said that the image drawn of a weak and powerless Iron and Steel Board "frustrated" by a recalcitrant iron and steel industry was wholly at variance with the facts. That the industry and the Board were usually in agreement demonstrated the correctness of the views arrived at by two knowledgeable and responsible bodies. The constant publicity in which the industry worked by reason of the duty and powers of the Board, Mr. Chapman remarked, ensured that no aspect of the industry's policy escaped comment or criticism. From the point of view of the public and particularly steel consumers, that was a far more satisfactory system than nationalisation. If, Mr. Chapman asserted, individuality and initiative were to be stifled by State ownership and if the benefits of the urge to compete were to be frustrated by bureaucratic centralised management, not only would the industry and those to whom it gave employment be adversely affected: harmful repercussions on the economy of the country as a whole, and therefore on its general prosperity, were bound to follow.

Films on Steel

A new film entitled "Drop Forgers in Steel," which is shortly to be released to educational and industrial organisations, has been produced by the film unit of the English Steel Forge and Engineering Corporation, Ltd. It begins with a general introduction to the plant used in the drop forging industry, and describes the metallurgical properties which the drop forging process gives to a component. Among the variety of drop forged components produced for the automobile, petroleum and aircraft industries, the manufacture of a four-throw crankshaft for a commercial vehicle is illustrated at all stages, from the machining of the die blocks and making of the steel to the finish machining and inspection. Another interesting sequence shows the forging under a 2-ton steam hammer of the oleo leg for the Vickers "Valiant" long-range bomber. "Drop Forgers in Steel" is a 16mm colour film and runs for thirty-five minutes. Applications for free loan should be made to the publicity manager, English Steel Corporation, Ltd., River Don Works, Sheffield, 9.

A second film, "Men of Consett," produced by the British Iron and Steel Federation and shown in London last week, is of more general interest. It is hoped soon to release it for public showing, particularly in the N.E. coast area. The film deals with the affairs of the Consett Iron Company, Ltd., and in particular with the lives of the people who work there. It is available on loan in 16mm and 35mm sizes and runs for twenty-five minutes.

World Exports of Manufactured Goods

According to the *Board of Trade Journal*, the value of world exports of manufactured goods in 1958 has been estimated at 41,847 million U.S. dollars, which was 2 per cent below the 1957 total. The value of world exports of manufacturers, which had been lower in the first nine months of 1958 than in the comparable period of 1957, recovered slightly in the fourth quarter and was, in fact, 1 per cent higher than in the comparable quarter of 1957.

United States exports of manufactures continued to fall in the fourth quarter, though at a slightly lower rate than from January to September; for last year as a whole, they were 12 per cent lower than in 1957. The United Kingdom's share in world exports was only marginally lower last year than in 1957; the fact that the fall in the United Kingdom's share has virtually been arrested for the first time since the war was largely due to the fall in United States exports. United Kingdom exports of manufactured goods were 2 per cent lower in 1958 than in 1957; the rate of decline was, however, markedly slower in the fourth quarter than in the first nine months of 1958. Exports of manufactured goods by the German Federal Republic continued to increase in the fourth quarter of 1958 and for the year as a whole were 4 per cent higher than in 1957.

The Machine Tool Industry

Speaking at the annual meeting of Asquith Machine Tool Corporation, Ltd., last week, the chairman, Mr. Robert Asquith, expressed the view that the Government's anti-inflation policy was in some part responsible for the reduction in new business in standard lines of British machine tools. He acknowledged that certain steps had been taken to ease the full force of those measures and thought it was possible that the recent slight improvement was the result. But, he urged, if the Government could see its way to reinstate the investment allowances, that step, more than any other, would encourage the buyers of capital equipment to hasten the purchase of new machinery and plant.

Another problem, Mr. Asquith said, which had contributed to the difficulties of the machine tool industry during the past year had been the Ministry of Supply's policy of disposals of machine tools from Royal Ordnance Factories which were being closed and of machines accumulated at the time of the Korean war which had since been kept in store. The appearance of these machines on the market for disposal at prices which, in the majority of cases, bore no true relation to their current cost, had complicated an already difficult problem. As the position stood at the moment, Mr. Asquith commented, it was likely to present an even more serious problem during the current financial year. The machine tool industry had pointed out at the highest level the serious repercussions which might result if this disposals policy was continued.

Miners' Hours and Holidays

At the end of January, the National Union of Mineworkers submitted to the National Coal Board claims for shorter hours and longer holidays. These claims included a seven-hour day for underground workers, a forty-hour week (inclusive of meal times) for surface workers, and a third week's annual paid holiday. The joint national negotiating committee for the coal industry met in London last week to receive the Board's reply. It was there stated that the Board was unable to agree to the claims, mainly because of the heavy financial burdens they would add to the mining industry at a time when it was striving to preserve the markets for coal against price competition. The union's representatives on the negotiating committee said, in reply, that "they reserved to themselves the right to refer the claims to the industry's National Reference Tribunal."

Scotland's Industries

In his annual statement as governor of the Bank of Scotland, Lord Bilsland comments on unemployment in Scotland. The figure (4·8 per cent of the insured population) is, he says, higher than in any other region. But, he adds, while that figure is low compared with unemployment experienced in the 1930s, the relatively unfavourable position of Scotland emphasises a continuing lack of balance in the Scottish economy. This position, the statement continues, arises from too great dependence on heavy industry and an inadequate representation of industries supplying consumer goods. The insufficient development of such industries, which are much less affected by credit restriction and changes in the trading pattern, both internal and in the export markets, has resulted in a lower rate of expansion of industrial activity in recent years and has increased the effect on Scotland of the recession in trade.

Nevertheless, Lord Bilsland goes on to say, it is gratifying to record that progress is being made towards achieving a sounder position. Notwithstanding restrictions in capital investment, 500 new factories and major extensions, totalling more than 15,000,000 square feet of space, have been built in Scotland, mainly in the industrial belt, in the last five years.

Hoesch Broad Strip Mill

A hot rolling mill for strip up to 1600mm width was commissioned a few months ago by Hoesch-Werke Aktiengesellschaft, Dortmund. It is a semi-continuous plant, with a nominal monthly output capacity of 44,000 tonnes, a figure which could, if necessary be quadrupled by the installation of additional furnaces and coilers and a second slabbing mill. The design represents a synthesis between current Continental and American practice. The plant includes a pusher furnace heated by blast-furnace gas. Extensive precautions had to be taken to enable the effects of possible mining subsidence to be corrected.

AS the third broad strip rolling mill in the German Federal Republic, the new hot-strip mill of Hoesch-Werke A.G., Dortmund, was completed in May of last year and has been in production for the last few months, with a monthly output of coils of 40,000–45,000 tons. The installation, stated to be the largest single investment made by the company, supersedes an earlier broad strip mill of which the first and second stages had been built, respectively, in the years 1938–43 and 1952–53. This consisted of a cogging mill and Steckel reversing finishing train, and already at the time of its full expansion to a capacity of 24,000 tons per month, was not capable of meeting the growing quantitative and in particular the high qualitative demands. A completely re-planned installation was therefore decided on in 1954, and work on the project commenced early in the following year. As with all modern plants of this kind, the demand for building space was considerable, but fortunately it was possible to expand in a direction which not only gave improved rail access from the steel works, but also allowed the old mill to remain in production.

By contrast with the two other German broad strip mills, the Hoesch plant is semi-continuous comprising a reversible slabbing mill, reversible roughing stand and five finishing stands. With the present installation, output is limited by the furnace and coiler capacity. In the second stage, therefore, the plant will be provided with a second pusher furnace and more pit furnaces, as well as a second coil winder. This will raise its monthly output of coils to 88,000 tonnes. If necessary, this last figure can be doubled by installing a second slabbing mill as well as additional pit furnaces, two more pusher furnaces, and a third coiler. Provision has also been made for a second roughing stand to be installed.

In the existing slabbing mill, which has an output capacity of 72,000 tonnes per month, 8-ton ingots are converted into slabs 180mm thick and 1300mm wide. Slabs of 1600mm width, which is the maximum the mill can handle, at present have to be brought in, but with the projected second slabbing mill it will be possible to roll blocks of 14·3 tonnes into 12·5-tonne slabs of the full width of 1600mm. The slabs are cropped in a 1500-tonne shear after which they can be traversed to a waterwheel which provides an even cooling. The cooled slabs are flame-gouged and passed into storage, whence they are transferred as required to the pusher furnace.

This furnace, shown in Fig. 1, has a nominal capacity of 100 tonnes per hour. By contrast with the American Rust furnaces which are designed for coke oven gas or oil firing, the present furnace uses blast-furnace gas of which there is a surplus. It is a five-zone furnace with unusually high combustion chambers (6m) so as to compensate for the lesser radiation of the blast-furnace gas by increasing the radiating area. The low calorific value of the gas (1000 k/cal per Nm^3) requires a larger gas volume to be used and therefore necessitates larger pipes, blowers, and flue ducts. Admixture of coke oven gas is possible at the burners, so as to raise the calorific value of the mixture to up to 2000 k/cal per Nm^3. The hearth is 28m long, 7m wide, and 6m high, and is served by forty-two burners.

Slabs of 6400mm length, and varying in width between 800mm and 1600mm and in thickness between 100mm and 200mm, have to be heated to about 1280 deg. Cent. To reach this temperature, the blast-furnace gas has to be preheated to 480 deg. Cent. For this purpose, steel tubular recuperators are employed. These utilise the flue gases as they come from the ceramic recuperators used for heating the combustion air to 700 deg. Cent. The recuperators are placed symmetrically, two on either side of the furnace, each group being served by its own fan.

An electrically-operated double pusher mechanism feeds the slabs through the furnace, from the output end of which they slide on to the intermediate roller bed which has a speed of 2·5m per second.

The roughing stand (seen in our title illustration) is a universal four-high mill with work rolls of 950mm diameter and a length of 1800mm, and support rolls of 1340mm diameter and a length of 1756mm. Vertical rolls of 1000mm diameter are arranged 2·6m in front of the horizontal rolls.

The drive comprises two motors, each of 3400kW, 56/112 r.p.m., for the twin horizontal drive, and two 400kW, 265/660 r.p.m. motors for

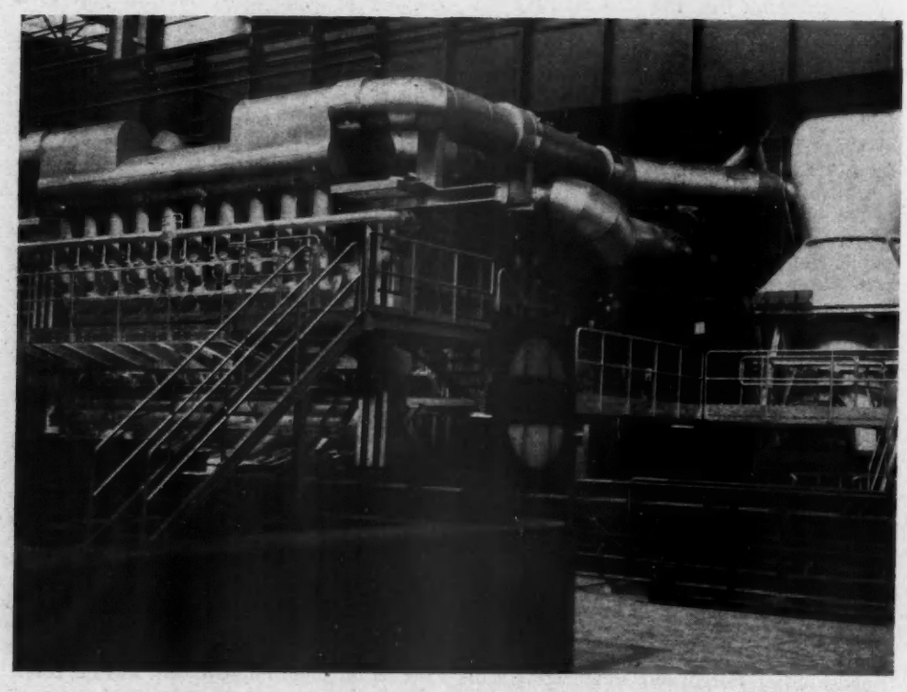


Fig. 1—The 100-tonne per hour pusher furnace is heated by blast-furnace gas. The furnace is here seen from the output side. The five-zone hearth measures 28m by 7m by 6m high, and is heated by 42 burners. Both air and gas are preheated

Fig. 2—Five-stand continuous finishing mill which operates with output speeds of up to 12m/sec

the vertical rolls. Each pair of motors is driven by a separate generator of a 5000kW 3-phase Ilgner set.

Auxiliary d.c. drives totalling 1800kW are supplied from three Ward-Leonard sets; the remaining auxiliaries are three-phase and amount to 2800kW. The total installed capacity of the roughing train is thus 12,200kW.

In five or seven passes through the roughing stand, the slabs are reduced to 15–25mm and then run out on to a reversible roller bed where they are cropped, descaled by water jets at 10 atmospheres pressure, and cooled down to the correct rolling temperature.

The strip then reaches the finishing train (Fig. 2) where the thickness is reduced in successive passes down to the required value. At present, strip 1·5mm to 10mm thick is being produced, the smallest thickness, however, only in widths up to 1000mm, while for wider strip the minimum thickness lies around 2–2·5mm. Provision has been made to install a sixth finishing stand later, so as to make possible a still lower finish thickness. All finishing stands are four-high, with work rolls of 650mm diameter and a length of 1730mm and support rolls of 1300mm diameter and 1700mm length. The latter run in "Morgoil" bearings. The stands are individually driven, each by a 3700kW,150/375 r.p.m. d.c. motor, the motors being supplied from five banks of twelve water-cooled mercury arc rectifiers. Auxiliary d.c. drives totalling 2600kW are supplied by three Ward-Leonard sets. Three-phase drives, including the coil conveyor, amount to 700kW. Altogether, the finishing train and its auxiliaries have an installed capacity of 21,800kW.

Following final reduction, the strip passes over a 60m-long cooling bed where its temperature is reduced to 550 deg. to 750 deg. Cent., and is then wound into coils of up to 12 tonnes by an underfloor coiler (Fig. 3) which afterwards transfers the finished coil to the first of a series of three successive plate conveyors arranged on three sides of a rectangle, with transfer turnpikes at the corners.

The strip temperature at the coil winder can be held within ±10 deg. Cent. The machine itself is designed for a coil weight of up to 9 kg per millimetre, which, however, cannot at present be fully attained. During the passage over the 135m-long system of plate conveyors, the coils are cooled down to temperatures at which they can be handled without deformation. They are then weighed and put into storage.

Water Supply

For cooling purposes a large quantity of water is required, amounting to 4400 cubic metres per hour with a static head of 48m. Of this total, 2300 cubic metres per hour are boosted to 120m static head and used for cooling the finishing rolls and the finished strip. The remainder is employed for cooling purposes in connection with the furnaces, the slabbing and intermediate mills, and for the rinsing of the scale channels, and for supplying the high-pressure descaling plant.

With a monthly output of 44,000 tonnes about 25 tonnes of scale are produced daily. This scale is washed down gutters with a gradient of 3 per cent, and deposited in two sumps, from where the contents are pumped to two 1100 cubic metre settling basins. To pass through each basin the water takes twenty-four minutes, and, having thus been cleansed of coarse sinter and oil, is pumped to a filtration plant of 240 square metres filter area (twelve gravel beds of 5m diameter). It then flows through a cooling tower and is afterwards recirculated. For cooling the electrical machinery and the rectifiers, colder water is required which is obtained by bleeding-off a quantity of 750 cubic metres per hour and cooling it further in a forced convection cooling tower. After use this water is returned to the works mains for re-use in the mill.

Installed pumping capacity totals about 14,000 cubic metres per hour, while the return pumping capacity to the purification and cooling plant is about 20,000 cubic metres per hour. This high figure arises from the fact that each pump stage comprises an electric pump together with one or two diesel emergency standby sets. About 12km of water mains and 4km of mains for steam, compressed air, and gas, have been installed.

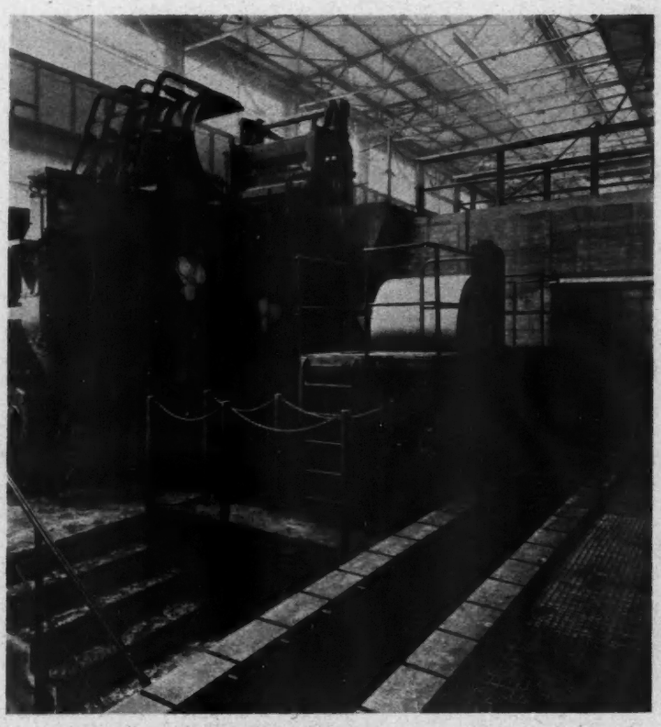


Fig. 3—Underfloor coiler with a capacity of up to 9 kg per millimetre. The coiling and handling mechanisms are operated by compressed air. A coil is shown on the unloading cradle which tips it on to the plate conveyor on the right

Electricity Supply

The whole of the electrical installed capacity amounts to approximately 40MW, or 20 per cent of the work's previous total consumption. The substation is equipped with two 110/30kV, 30MVA transformers which in turn supply the five transformer-rectifier sets of 4MVA for the finishing stands. A 30/5kV, 20MVA transformer supplies the 5kV system, to which are connected the Ilgner converter for the drives of the intermediate stand, the converters for the auxiliary drives, six 5/0·4kV, 1600kVA transformers for switchgear operation, and a 380V supply for the descaling plant. The principal electrical equipment is housed in a separate 160m-long building of 9m width and 11m height.

Buildings

The building work involved the longitudinal extension of two parallel bays from 21,000 square metres to 61,000 square metres. Width and height of the new halls were determined by the desire to use both the old and the new travelling cranes in both parts by extending the old crane rails into the new section. The individual length of the new halls is about 700m, and the combined width, 130m.

The foundations required 600,000 cubic metres of earth movements, 53,000 cubic metres of reinforced and prestressed concrete, and 130,000 square metres of shuttering. The structural steelwork amounted to 13,000 tonnes, reinforcement steel to another 5000 tonnes.

Considerable precautions had to be taken because the site is subject to mining subsidence. To limit the effect of subsidence on the building the bays are subdivided into six independent sections separated by joints. The steelwork is statically determinate, using three-pin portal frames. All stanchions are supported on spherical seatings and can be shifted longitudinally, while the crane tracks can be shifted transversely on their brackets to maintain the correct gauge.

The main problem was, however, to maintain the alignment and level of the various parts of the rolling line. In particular, the finishing stands which operate on a continuous mill, are very sensitive to misalignment and tilting. The coil winder, too, has to be kept in its correct position rather accurately.

For these reasons the finishing stands were mounted on a single, prestressed concrete base comprising a diamond-pattern system of main beams, with a 50cm thick deck. This base, which has a weight of 4000 tonnes, rests in three points on a 4800-tonne concrete substructure. The weight of machinery mounted on top of the base is 4200 tonnes.

The three-point supports allow vertical corrections of up to 30cm and movements

of 25cm in any horizontal direction. Each support takes the form of a heavy steel casting with spherical seating. Between the upper flat surface of this bearing and the concrete is placed a sliding plate. A film of pressure oil between the steel casting and the plate permits the top to be moved laterally. At the main support are arranged twenty-two jacks, each of 500 tonnes capacity, and at each of the subsidiary supports six jacks of similar capacity. These jacks are operated with an oil pressure of 400 atmospheres, and enable vertical adjustment to be carried out by inserting the required number of shims.

For the coiler (which is situated below floor level) the foundation takes the shape of a pre-stressed concrete trough supported at its four corners. The side walls act as load-bearing beam members which between them support the base plate. The latter is comparatively elastic, so that it can undergo much deformation through unequal subsidence of the supports, without risk of fracture. The displacements must, however, be corrected, and in order to detect any deflection in good time, a system for continuously checking the levels has been installed. This consists of a ring main filled with oil which acts upon floats which are connected to electrical contacts and so operate a series of lights.

Production Programme

Present production covers strip from 550mm to 1600mm width, in thicknesses from 1·5mm to 10mm, as has been stated. The steel qualities cover rimming and killed soft steels for subsequent cold rolling or hot sheet rolling, carbon steels up to 70 kg per square millimetre, special steels for pipe manufacture, and transformer and dynamo sheets.

Main Contractors

Five-stand finishing mill, roller beds, and coiler: Demag A.G., Duisburg. Roughing stand and roller beds: Siemag, Dahlbruch. Main and ancillary electric drives: AEG Allgemeine Elektricätsgesellschaft, Berlin, and Siemens-Schuckertwerke A.G., Berlin and Erlangen. Substation transformers and switchgear: Brown Boveri et Cie, Mannheim. Steel structures: Jucho, SAG, Aug. Klönne, H. Rüter, Albert Liesegang. Foundations: Wiemer and Trachte, Hochtief A.G., Wayss and Freytag, Meyer and Wiesner. Pusher furnace: Westofen G.m.b.H. Wiesbaden, Siemen and Halske A.G. (controls), Gesellschaft für Industrie Wärme m.b.H. (recuperators).

Rotterdam-Rhine Pipeline

Disregarding temporary fluctuations of economic activity, the European oil industry estimates that demand for petroleum products in Western Europe will nearly treble by 1965. *Such an expansion calls for the installation of further refining capacity and the construction of pipelines to feed the refineries and associated chemical works. We recently described the North-West Oil Pipeline which links Wilhelmshaven with the Rhineland. Another pipeline, now under construction, will connect the Rhineland with Rotterdam.*

THE development of pipelines for the transport of petroleum dates back to 1865, when the first pipeline was put into service in the U.S.A. Consisting of screwed 2in cast-iron pipes, it covered a distance of 8·5km, and the transport charge per barrel amounted to 1·25 dollars. To-day, 2400km can be covered for half this amount. In 1880 there were already in existence 2000km of pipelines in four States. At the present time the United States have in operation a network for petroleum and derived products which extends through forty States and totals some 280,000km; in addition there is a pipe network for natural gas of 322,000km length. The tonnage transported through pipes amounts to about one-eighth of the whole of the commercial traffic.

European developments are by comparison on a very modest scale. Nevertheless, as consumption increases—and a threefold expansion is envisaged by 1965—refineries and petrochemical works tend to move inland, away from the seaports through which supplies arrive, and nearer to the sites of utilisation. Already the point is being reached where rail and road transport, and even major arteries of inland navigation, such as the Rhine, are loaded to capacity, and the construction of pipelines becomes essential.

In addition to the now operational North-West Oil Pipeline between Wilhelmshaven and the Rhineland which we described in a recent article,* there is under construction a second pipeline between Cologne and the port of Rotterdam. By the middle of 1960, this 300km long connection will be in service.

While the production of coal remains pretty well constant over a period of years, while water power is available only in restricted measure and nuclear energy cannot yet be produced in commercial quantities, oil helps to meet the rapidly increasing demand for energy in the whole Rhine basin.

Home production of oil in these countries, which in a few years has risen to a yearly amount of nearly 4,000,000 metric tons in West Germany and to 1,500,000 metric tons in the Netherlands, is not by a long way able to meet these requirements.

* February 27, 1959, page 356.

Rotterdam plays a leading part in the import of crude oil from the Middle East and Venezuela—to name only two sources. Of the 74,100,000 tons of goods handled in 1957 by this port, 30,000,000 tons were oil and oil products.

Two refineries downstream from Rotterdam process a major portion of the several crudes, dealing with about 15,000,000 tons a year. Of these, 12,500,000 tons were processed by Shell and 2,500,000 by Caltex.

Beginning in 1946, a tank farm has been under construction on a part of the sites of the Shell Pernis refinery, which lies halfway between Rotterdam and The Hook on the south bank of the Maas. Part of this tank farm is intended for storing crude oil, which will be processed in refineries in the West German industrial area.

Caltex too will receive oil from abroad in this way in its own tanks and these two companies, together with the Gelsenberg and Mobil Oil Handels- und Transport-Gesellschaft m.b.H., will use the pipeline now under construction to convey crude oil eastwards—initially 7,500,000 tons per annum and rising to a maximum of 20,000,000 tons—independently of weather conditions.

Last summer a combine of Dutch and German contractors, assisted by American experts, started laying the pipeline, which has a diameter of 24in and will be covered by at least 60cm of earth throughout its length.

The N.V. Rotterdam–Rijn Pijpleiding Maatschappij was founded on April 3, 1958. The first sections of piping were brought from Germany to the port of Maassluis at the beginning of July. The pipes are given anti-corrosive wrappings, are welded together along the route and—with additional cathodic protection—laid in a trench and covered with earth. In September 2000 yards of pipeline were laid across the bottom of the Hollands Diep.

On its way, the Rotterdam–Rhine pipeline will have to cross not only rivers, but also numerous dykes, roads and railways. To do this, a method which consists of boring an opening through which a "casing pipe" is pushed, will be used. Sections of the pipeline are placed inside this casing pipe.

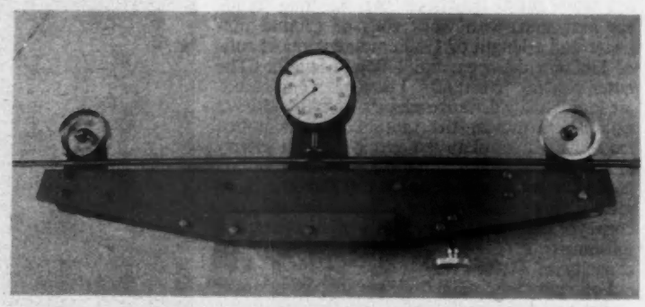
The pipeline will pass over roughly 160km of Dutch territory. The route runs south-eastwards from Pernis across Ijsselmonde and Beijerland to Moerdijk. From there it runs in an almost straight line to a point north of Venlo. Negotiations on the routing of the two branches on German territory are now about to be completed: the whole system will be ready for use by the middle of 1960.

The three partners intend to use the pipeline for supplying crude oil to the existing refinery of the Gelsenberg Benzin A.G. at Gelsenkirchen, to the refinery of the Deutsche Shell A.G. at Godorf, near Cologne, which is now under construction, and to the Caltex Tankkraft A.G., also near Cologne.

At the moment laden tankers of up to 45,000 tons can berth in the first and second petroleum dock, but a deepening of these basins is already on the programme. For berthing very big ships, however, it will be necessary to wait for the opening of the fourth petroleum dock, for which dredging operations were started on September 13, 1958.

Rope Tension Gauge

There exists frequently a need for finding the tension of ropes, traction conductors, aerials, and similar overhead wires. For this measurement it is usual to use a dynamometer which, however, makes it necessary to disconnect an already installed wire. This disadvantage is avoided by the "SY" rope tension gauge, manufactured by Hans Schmidt, Esslingen/Neckar, and handled in this country by Addison Electric Company, Ltd., 10–12, Bosworth Road, London, W.10. Covering a range of 440 lb to 3300 lb—special versions for higher tensions can be produced—the gauge operates on the principle of measuring the lateral deflection under a known load. As our illustration shows, it consists of a beam, made of light alloy, with steel pulleys near the ends under which the rope or wire is passed. A central spring loaded pulley, mounted on a ball-bearing-supported arm, pushes upwards against the wire, and a dial gauge measures the deflection. In normal working, as shown here, the gauge is balanced to hang vertically. It can, of course, also be applied to a vertical or sloping wire. Measurements are taken by cocking the arm of the centre pulley, placing the gauge in position, and adjusting the dial gauge to zero. The arm is then released and a reading of the deflection is obtained. By means of tables supplied by the maker, these readings can be converted into tensions for wire sizes ranging from $^{5}/_{32}$in to $\frac{1}{2}$in diameter. The instrument has a gauge length between the centres of the outer rollers of 23½in, and weighs 6½ lb. An accuracy of ±1 per cent is claimed, but in order to achieve this the length of rope between supports must be 16ft or more. The same measuring principle has been applied to instruments for the ranges 0·3 g to 10 kg and 1 kg to 100 kg.



Gauge for measuring tension in a rope or wire while under load, by reading on a dial gauge the lateral deflection under a standard force applied at the centre of the gauge length

The American Scene

BY OUR AMERICAN EDITOR

New Prospects for Titanium

In the past eighteen months, titanium —that post-war metallurgical prodigy—has undergone a remarkable series of ups and downs. After a meteoric growth—in barely a decade, production soared from less than 3 tons of sponge metal to 17,500 tons—and a slump in 1957 and 1958, which put a number of major producers out of business, the industry seems at last to be on the rocky road to recovery. The U.S. Defence Department remains to-day, as always, the biggest user of titanium. But it also is going into both engines and structural parts of the new jet airliners. It is finding markets in shipbuilding, and in the processing of food and chemicals. It is being used in piping and valves, in computers and electron valves, in costume jewellery and dental braces. Moreover, new applications constantly are being discovered for the light, tough, heat-and-corrosion-resistant metal.

In America, the industry which produces and processes titanium is divided roughly into four parts. First come the companies which mine the basic rutile and ilmenite ores from which titanium is derived. Then follows conversion of the ores to the next stage, titanium tetrachloride, followed by the processing of the tetrachloride into sponge metal. The final stage of fabrication into sheets, bars and billets is handled both by relatively small firms, such as Oregon Metallurgical and Harvey Aluminum, and by such giants as Republic Steel, Crucible Steel and Mallory-Sharon. But by far the biggest producer, accounting for about half of all the industry's output, is the Titanium Metals Corporation of America, which is owned jointly by National Lead and by Allegheny Ludlum Steel. T.M.C.A. participates in all four stages of production and is the only fully integrated American concern in titanium to-day.

The industry lately has had its troubles. None of the companies has been running anywhere near capacity. In all of 1958, total shipments came to 5,200,000 lb, compared to 11,300,000 lb in 1957. As a result, no one in the business made any money on titanium operations last year. Several firms found themselves unable or unwilling to wait out the slump. Kennecott Copper and Allied Chemical, which had joined to form the Allied Kennecott Titanium Corporation, shelved indefinitely plans for building an integrated processing plant. Dow Chemical suspended production. Cramet, set up by Republic Steel and the Crane Corporation, simply turned its plants back to the U.S. Government and went out of business. However, a pickup in the industry now is clearly under way. From a low of 189,000 lb in November, 1957, production gradually advanced to 520,000 lb last December. As for 1959, total mill product shipments are being estimated at about 7,500,000 lb, against the 5,200,000 lb in 1958.

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Now some brightening of the industry's prospects is in sight. Casting remains a major problem, but most of the other technological difficulties have been solved. Rolling, forging and extrusion are standard operations. Most welding and machining can be done easily. Heat treating and annealing are carried out under closely controlled atmospheric conditions. In the tasks for which it is especially suited, titanium is hard to beat. At room temperature, its alloys are the equal of other heat-treated materials and weigh 40 per cent less. Where strength-to-weight factors are about the same, and the cost of other metals is less, as in some magnesium and aluminium alloys, titanium still has the edge at temperatures ranging from 500 deg. to 1200 deg. Fah. Titanium's corrosion resistance also is remarkable—in some cases it is ten to fifty times that of other materials. The metal is not affected even by concentrated, boiling nitric acid. It is proof against the destructive inroads of sea water, brine, and atmosphere, as well as dilute sulphuric, hydrochloric and phosphoric acids. Neither acetic, citric and tannic acids nor inorganic alkalis have much effect on it.

Furthermore, the industry to-day is reducing steadily titanium's once-exorbitant price. The original 5 dollars a lb for sponge had come down only to 4·50 dollars by the end of 1954. In successive stages, it then dropped to the present level of 1·82 dollars last October. Mill products have shown a parallel trend. Their composite price has stepped down from 15·25 dollars a lb in 1954 to 7·77 dollars to-day. Both sponge and mill products are likely to be trimmed even more in the coming year. Further progress in this direction will be more than welcome, since the price of titanium still is three to four times that of comparable grades of stainless steel. Agreement is almost general in the industry that the sponge will sell for 1·50 dollars a lb within the next few years, and there is some expectation that the mill products can be brought down to as little as 2·50 dollars a lb eventually. Probably the most important factor in reducing the price both of sponge and of mill products will be the achieving of large-scale output. The producers have set their sights on putting into operation plants with capacities of 20,000 tons or more, compared with 6000 to 10,000-ton plants to-day.

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caused by the military budget " stretch-outs." The metal not only is being used in the Boeing " 707," but also is going into the Convair " 880 " and the Douglas " DC-8." A " 707 " uses about 1000 lb of it ; an " 880 " or " DC-8 " almost 2500 lb. While most of that weight still goes into engines, an increasingly important use for the metal has been found in the airframe itself. The biggest advances in the civilian consumption of titanium have come in the various processing industries. In many cases, the corrosion resistance of titanium has cut the cost of replacement equipment sharply, more than offsetting a higher initial outlay. For just such reasons, titanium is winning ever wider acceptance in applications involving tubing, piping, coils, heat exchangers, valves and agitation equipment. Finally, titanium is playing a growing part in shipbuilding, where resistance to salt water corrosion has made it the ideal metal for marine fittings and piping. How fast and how far titanium will travel along the road to economic health is not easy to predict. The initial impetus, Government sponsorship, is gone. The end of stockpiling has forced the producers now to rely on their own selling abilities. While the military probably will continue as the No. 1 customer, Washington no longer offers the cushion of a guaranteed market. Consequently, the titanium concerns are spending considerable funds to-day to find and promote new users for the metal. Once a mill product price of 2–3 dollars a lb is reached, the industry estimates that 20,000–30,000 tons a year of the metal will go into military aircraft, 15,000–20,000 tons into chemical processing equipment, 10,000–15,000 tons into trucks and buses, and 2000–3000 tons into automobiles. These figures perhaps err on the side of optimism. Nevertheless, the outlook is reasonably bright. If the climb back to former output levels and beyond will be difficult, there is little doubt that the industry at last is on its way.

Automatic Steel Bar Processing Line

A COMPLETELY automatic high-speed machine for the continuous cold drawing, straightening, cutting and polishing of bars from coiled rod is now in full production at an American steel works. Capable of turning out high-quality cold-finished rounds, squares, hexagons and rectangular sections in sizes from $\frac{3}{16}$in to $\frac{1}{4}$in, the entire installation has the exceptionally high line speed of 200ft per minute. In the production of $\frac{1}{4}$in rounds, this speed results in an output capacity of 5 tons per hour, based on 20 per cent down-time for coil feeding and tooling changes.

Designed and built by the Loma Machine Manufacturing Company, of New York, the so-called " Lomatic " machine has been installed for the production of cold-finished carbon, alloy and leaded steels. Compared to conventional, separate rod drawing, straightening, polishing and cutting-to-length operations, the new single-operation machine offers the following major advantages :

(1) Greater output rate—continuous operation at high speed.

(2) Reduced labour cost—only one operator is required.

(3) Improved straightness—stock is straightened in two planes.

(4) Perfect concentricity—obtained by straight-line drawing action.

(5) Higher surface finish—due to two-stage polishing unit.

The complete line comprises an uncoiler, a prestraightener, a drawbench, a roller straightener, a flying cut-off, a polishing machine and a discharge table. All components required for the complete sequence of processing operations are interlocked mechanically and electrically into one integrated and synchronised line which is controlled by only one operator. In a representative finishing operation, coils of hot rolled, pickled and limed rod weighing about 1000 lb are loaded on to the uncoiler or pay-off table of the line, and one end of each coil is pointed on either a swaging or turning machine. The machine operator has ample free time during the run of a coil through the line to point the next coil without requiring the assistance of a helper.

Continuous Drawbench

The remarkable productivity of the " Lomatic " line is largely due to its continuously operating high-speed heavy-duty drawbench which allows a substantial cold reduction to be applied to the material prior to straightening, polishing and cut-off. The drawbench is of rugged design, allowing an 8000 lb continuous pull to be exerted at 200ft per minute line speed. The resulting reduction greatly improves the surface quality of the stock and produces a closely held bar size.

The coil of rod resting on the uncoiler is inserted into the five-roll prestraightener which serves to remove the coil bend and to eliminate any kinks. Upon leaving the prestraightener, the stock is pulled continuously through the tungsten carbide die by the back-and-forth movements of two carriages with built-in jaws, effecting a reciprocating movement, so that one carriage moving forward pulls the rod through the die while the other carriage moves back. The gripping jaws are closed and opened automatically by an electro-pneumatic servo system when the movement of the carriage is reversed. The movements of the carriages overlap in such a way that a continuous uniform advance of the stock through the die is obtained. The back-and-forth movement of the two carriages is controlled by cams cut into two rotating drums disposed underneath the frame of the drawbench. These drums are operated from the main motor, which is connected to the drum shaft by a gear drive. Special provision is made for the adjustment of the carriageways, to obtain the closest possible fit, free of play.

The gripping jaws built into the carriages are of great length and of a special shape, so that they contact the rod from several sides and operate under a low specific pressure. This feature eliminates the risk of surface marks being applied to the material by the pulling action. The drawing die is mounted in a rigid cast iron die stand. It is lodged in a die holder of spherical shape so that its correct position can readily be adjusted to ensure the straight-line advance of the stock through the drawbench. Upon the insertion of a new coil, its pointed end is gripped by auxiliary jaws attached to the first carriage. This point may be very short, since the carriage moves close to the die.

Roller Straightener

The rod emerging from the drawbench passes through a vertical and a horizontal set of straightening rollers mounted in tandem. Each roller straightener comprises eight rollers, four of which are positively driven through gearing by a common motor. To provide the straightening effect, the rollers are adjustable by handwheels which actuate the adjusting screws of the roller sliding saddles. Accurately calibrated scales are provided to facilitate the exact setting of the saddles. The rollers are mounted on overhung shafts and are thus not obscured in any way, the operator having a clear view of the stock along the entire length of the straightener. This design makes the adjustment, operation and changing of rollers very simple. The rollers are made of tool steel and have ground and polished faces hardened to Rockwell C-56 minimum. Each roller is grooved to suit two sizes of stock and can quickly and easily be reversed or exchanged by loosening a nut and removing a horseshoe retaining washer.

Flying Cut-Off

The rod is cut into lengths ranging from 8ft to 25ft by a flying shear travelling in the direction of and at the speed of the advancing stock. The

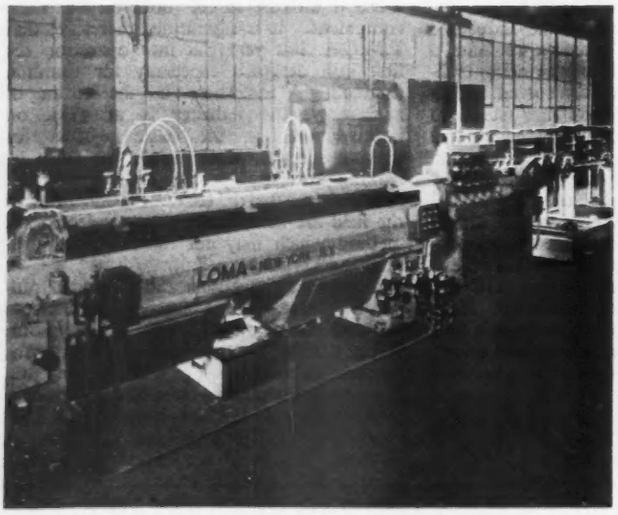


Fig. 1—Dual-carriage drawbench for the continuous drawing of rounds, squares, hexagons and rectangular sections

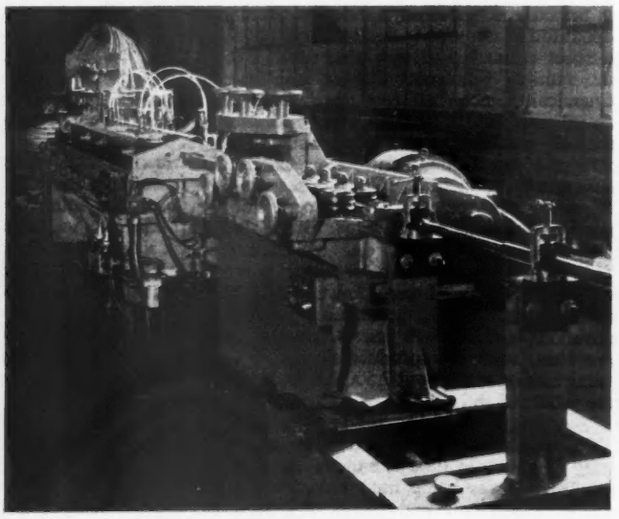


Fig. 2—Vertical and horizontal roller straighteners, each comprising eight straightening rollers

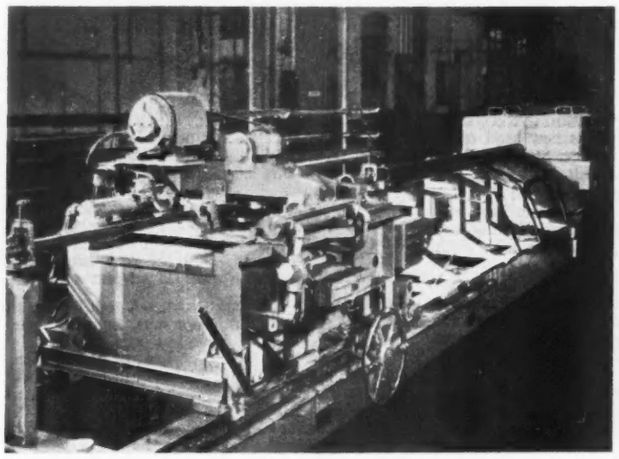


Fig. 3—Flying cut-off shear with discharge table and polishing machine at rear

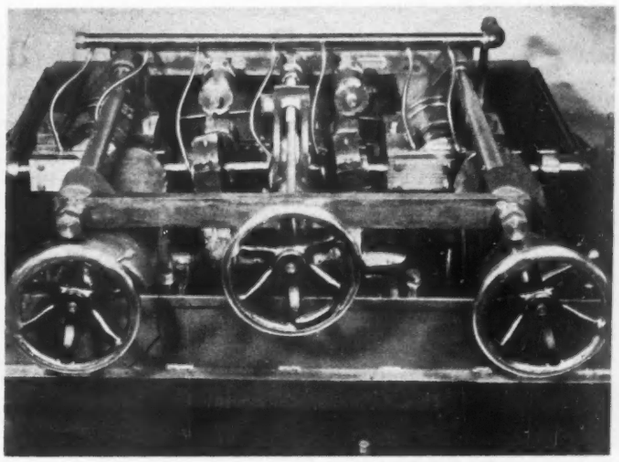


Fig. 4—Combined straightening and polishing machine, with twin sets of polishing discs and three straightening bushings

two cutters of the shear are mounted opposite each other on slides in the shear carriage, which can move back and forth between guides built into the shear frame. The slides which carry the two cutters are linked to levers in such a way that during the forward movement of the carriage, the cutters approach each other until the cut is made. After the cut, they open automatically at the end of the stroke of the carriage and remain open during the return stroke. The advance speed is synchronised with the line speed of the stock, whereas the return stroke is made at a faster speed.

The shear operation is enacted by the rod hitting a length-control limit switch mounted at the entry side of the polishing machine. The previously cut off rod is taken away by the polishing machine at a speed faster than the drawing speed, so that a gap is formed between any two subsequent rods. The cut-off length is determined by the distance between the length-control limit switch and the flying shear in its rest position. This distance can be varied in accordance with the required cut-off length by moving the entire shear along its supporting bed frame.

Polishing Machine

After cut-off, square, hexagon and rectangular stock is discharged into piling racks, while round stock is further processed in a combined straightening and polishing machine. It passes between two sets of motor-driven discs, disposed at the entrance and exit of the unit. The two discs of each set are mounted off-centre opposite each other and rotate in the same direction. The stock is conveyed under pressure between the discs, and due to the special shape of the hardened disc surface, the rod passes at a level slightly above the centre line of the rotating discs. This results in a combined rotating and advancing movement of the stock. The high pressure to which the stock is exposed when passing between the discs produces a highly condensed and polished surface on the stock. This 20 to 30 micro-inch R.M.S. finish frequently is preferred to the one obtained by centreless grinding and can be furnished by the mill without involving an additional operation. With the current accent on greater product quality in the United States, it is becoming increasingly important for steel mills to be able to offer such a superior surface quality as a cost-free extra.

Simultaneously, a precision straightening effect is obtained by the passage of the stock through three bushings situated between the two sets of discs. These bushings are adjustable out-of-centre and cause the spinning stock to bend in all directions, thus relieving any stresses left from the preceding drawing operation and ensuring perfect straightness in the finished rod.

Discharge Table

The finished product is discharged on to a table mounted behind the polishing machine. This table is sloped slightly towards piling racks placed alongside the table. If the rods roll freely over this slight incline into the racks, it indicates to the operator that they are perfectly straight, and that the straightener is correctly adjusted.

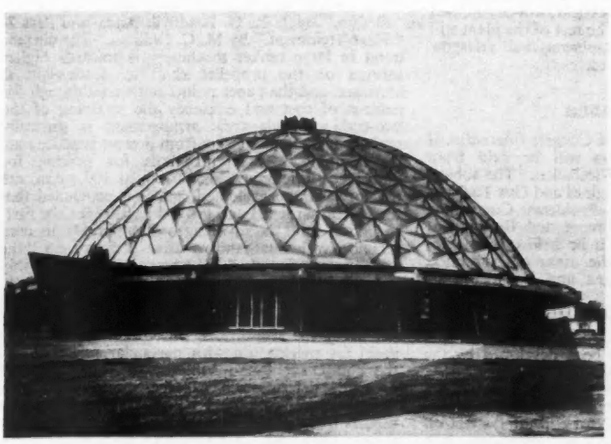
The accompanying illustrations relate particularly to a line installed for the processing of carbon, alloy and leaded steels. Several American copper, brass and aluminium works have also installed similar machines, including a larger model capable of handling stock from $\frac{1}{8}$in to 1in finished size.

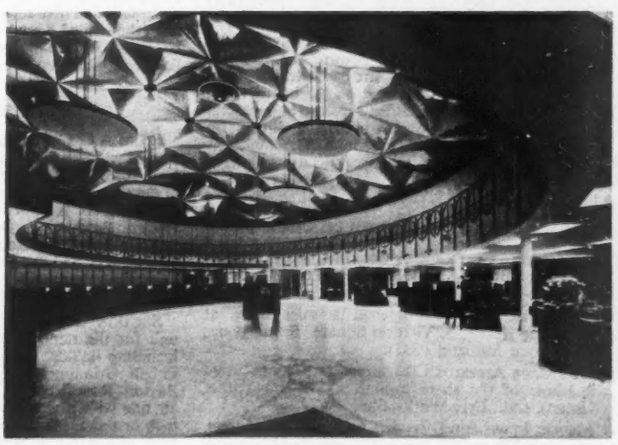
Stressed-Skin Aluminium Dome

The Citizens State Bank of Oklahoma City, Oklahoma, was recently opened in a new building covered by a gold-aluminium dome. The building is illustrated below. The dome rests on a circular concrete and glass exterior wall which also supports a 10ft cantilevered canopy around the building. The canopy adds architectural interest as well as protecting the two entrances, drive-up windows and night depository. The 625 diamond-shaped panels that make up the dome shell are anodised gold, while the struts which strengthen the panels are anodised black.

The stressed-skin aluminium dome was designed and developed by the Kaiser Aluminum and Chemical Corporation and is a clear-span structure. This building is 70ft high, with an interior diameter of 145ft. It has 17,500 square feet of floor space on the main floor, together with 9500 square feet in the balcony and 4500 square feet in the basement. The ceiling is a second, smaller, gold-coloured dome suspended 31ft from the floor. The general contractor for the project was the Secor Building Company of Oklahoma City, and the dome was erected by Dale Benz, Incorporated, of Phoenix, Arizona, a firm licensed by Kaiser Aluminum as a dome fabricator-erector.

The Citizens State Bank building is the sixth such stressed-skin aluminium dome erected in the United States during the past two years. A number of others are under construction or at various stages of planning. The principal advantages claimed for them are economy and speed of erection. A dome of larger diameter and of structural steel, but employing generally similar structural principles, was briefly described and illustrated in The Engineer of February 27 last.





Left—Exterior of stressed-skin aluminium dome building of the Citizens State Bank of Oklahoma City. Right—Interior of aluminium dome building with suspended dome ceiling

Personal and Business

Appointments

MR. P. H. LEYTON has been appointed director of engineering of Black and Decker, Ltd.

DEWHURST AND PARTNER, Ltd., announces that Mr. C. A. McLaren has been appointed works manager.

MR. J. S. BROUGH has joined Humphreys and Glasgow, Ltd., as technical director and general manager.

MR. R. W. HONEYWELL has been appointed representative for the Leicester area by Crofts (Engineers), Ltd.

MR. D. FRITH has been appointed as an assistant to Mr. J. T. GRUNDY, chief lighting sales engineer of Siemens Edison Swan, Ltd.

BRITISH RAILWAYS, Western Region, has announced the appointment of Mr. J. F. Bickerton, M.I.C.E., as district engineer, Newport.

MR. G. B. R. FEILDEN, engineering director of Ruston and Hornsby, Ltd., has been elected to the Fellowship of the Royal Society.

KLOCKNER MOELLER (ENGLAND), Ltd., has announced the appointment of Mr. Iain W. Trench as sales engineer for the Scottish area.

THE DAVID BROWN CORPORATION (SALES), Ltd., has appointed Mr. W. A. Griffin area sales engineer (South Wales) for its industrial gear division products.

MR. C. T. MELLING has been elected chairman, and Mr. S. E. Goodall, deputy chairman, of the National Inspection Council for Electrical Installation Contracting for 1959–60.

BRITISH RAILWAYS, Eastern Region, has announced the appointment of Mr. J. B. Manson, A.M.I.C.E., as district engineer, Peterborough, in succession to Mr. J. H. Glendinning, who has retired.

INTERNATIONAL COMBUSTION PRODUCTS, Ltd., has announced that Mr. W. G. Picton, a director of the company, has been appointed president of the Mechanical Handling Engineers' Association.

MR. W. M. LLOYD ROBERTS, the present deputy chief engineer of the Metropolitan Water Board, has been appointed to succeed Mr. H. F. Cronin, M.I.C.E. as chief engineer to the Board. Mr. Cronin is to retire on May 12.

MIDLAND HEATING AND VENTILATION COMPANY, Ltd., announces that Mr. A. G. Palmer, 29, Rothersfield Road, Carshalton, Surrey (telephone Wallington 6829) has been appointed sales engineer for London and the southern counties.

MR. REGINALD GEORGE GROUT, chairman and managing director of the General Steam Navigation Company, Ltd., is to succeed Major-General G. N. Russell as president of the Institute of Transport for the session commencing October 1, 1959.

F'AG BEARING COMPANY, Ltd., announces that Mr. I. Chisholm is to assume responsibility for the southern Scottish division of the company in April. He will work from the Glasgow office, 107–111, Albert Drive, Glasgow, S.1 (telephone Pollok 5531).

GENERAL REFRACTORIES, Ltd., announces that at the annual general meeting to be held on April 14, Sir Ronald W. Matthews will be succeeded as chairman by Mr. R. A. Kirkby. Mr. J. Gregory, production director, will take the position of managing director in June ; Mr. B. Eichler, director of research, has been appointed to the board, and Mr. A. McKendrick will retire.

REDHEUGH IRON AND STEEL COMPANY (1936), Ltd., announces that Mr. D. G. Brown, M.I.Mech.E., managing director, is to retire with effect from April 11, but will retain his seat on the board. Mr. E. J. McVitie, A.M.I.Mech.E., director and general manager, has been appointed managing director in succession to Mr. Brown, and Mr. T. H. Binnie has been appointed general manager in succession to Mr. McVitie.

Business Announcements

HUDSWELL, CLARKE AND CO., Ltd., states that its address is now 14, Howick Place, London, S.W.1 (telephone Victoria 6786).

CONCRETE, Ltd., has opened a sales office at Winchester House, 5, Victoria Square, Birmingham, 2 (telephone Midland 0331).

THE CAPE ASBESTOS COMPANY, Ltd., has acquired the whole of the share capital of William Turner (Kismet), Ltd., Eyre Works, Sheffield.

MESSRS. LEWIS AND DUVIVIER, Consulting Engineers, have moved from 122, Victoria Street, to 14, Howick Place, Westminster, London, S.W.1 (telephone Victoria 9127–9).

JOHN BROWN AND SONS (WOLVERHAMPTON), Ltd., has announced the opening of its new head office and works, at Chell Street, Hanley, Stoke-on-Trent (telephone Stoke-on-Trent 21531–3).

SINCLAIR OIL CORPORATION and the BRITISH PETROLEUM COMPANY, Ltd., have announced the formation of a jointly-owned company, Sinclair and B.P., Sales, Inc., Sinclair Oil Building, 600, Fifth Avenue, New York.

CHAS. H. WINDSCHUEGL, Ltd., 1, Leadenhall Street, London, E.C.3, states that it has been appointed sole agent in the United Kingdom for "Beverol" motor and industrial oils and greases manufactured in Holland by Beverolfabrieken N.V. of Beverwijk, Holland.

HOOVER, Ltd., states that it has concluded negotiations to buy outright from the Board of Trade the 282,000 square feet factory of Hoover (Washing Machines), Ltd., Pentrebach, Merthyr Tydfil, hitherto held on lease from the Board.

J. H. FENNER AND CO., Ltd., and associated companies, Marfleet, Hull, Yorks, have now been connected to the International Telex Service. Three branch offices have also been equipped with this service. The numbers are : Hull 52247 ; London 22405 ; Birmingham 33281 ; and Manchester 66169.

N.V. CURACAOSE DOK-MAATSCHAPPIJ (CURACAO DRYDOCK COMPANY INC.) announces the appointment of William King and Co. (London), Ltd., 22, Billiter Street, London, E.C.3, Mr. David A. Swan, 27, Leadenhall Street, London, E.C.3, and PHs. Van Ommeron (London), Ltd., 27, Leadenhall Street, London, E.C.3, as its joint representatives for the United Kingdom and Northern Ireland.

Contracts

D. NAPIER AND SON, Ltd., of Acton, London, has received from the East German Government a contract for aero-engine turbine blades worth approximately £100,000. The order, which is the first for castings to be received by Napier from an overseas customer, was secured in competition with both British and foreign firms, and was signed at Leipsig.

COOKE AND FERGUSON, Ltd., a member of the Crompton Parkinson group, has been awarded a contract by Durban Corporation for a new substation at Mitchell Park. The equipment to be supplied includes a five-unit FE5 single busbar, 33kV, 750MVA metalclad switchboard and a twelve-unit FTD 4/5 double busbar, 6·6/11kV, 250MVA metalclad switchboard. The value of the switchgear, excluding the control panels, which will be built in South Africa, will be approximately £36,000. The Cooke and Ferguson agent in South Africa is Arthur Trevor Williams (Pty.), Ltd., Johannesburg.

HUMPHREYS AND GLASGOW, Ltd., has been awarded a second contract by Japan to build plant for the production of gas from heavy fuel oil. Using the Onia-Gegi catalytic oil gas process, the plant, which is to be built at the Himeji works of the Tokyo Shibura Electric Company (Toshiba), will produce 500,000 cubic feet of gas a day. It will be commissioned at the end of this year and will replace obsolete coal-gas retorts. The gas will be used for heating processes used in the manufacture of electrical equipment. Catalyst and special equipment, such as pneumatic and hydraulic control gear, will be supplied from the United Kingdom. The rest of the plant will be made in Japan by Humphreys and Glasgow licensees, Ishii Iron Works, Ltd.

Miscellanea

C.I.M.A.C. CONGRESS.—The Congres International des Machines á Combustion will be held from June 14 to 19, inclusive, at Wiesbaden. The subject of the Congress is "Diesel Engines and Gas Turbines up to 1500 h.p., Current Problems Concerning Design, Production, Development and Running at Site." Technical sessions will be held on June 15, 16 and 17, and works in the areas of Augsburg, Stuttgart, Mannheim, Cologne and Essen will be visited on June 18 and 19.

SUCTION UNIT FOR WASTE REMOVAL.—A suction unit for the removal of all kinds of factory waste, including liquids, which has been developed by the Exhall Grinding and Engineering Company, Ltd., Bayton Road, Exhall, Coventry, operates off any air line with a working pressure of 80 lb per square inch or more. It can be used for collecting swarf off machines or for emptying suds and oil tanks. The unit, with a weight of only 14½ lb, is easily portable, and its container is 16in high by 11in diameter.

GROUND ROUND STOCK TOOL STEEL.—A high grade tool and die steel is now being produced by George Sorby, Ltd., Sheffield, as ground round stock. This oil hardening steel, it is stated, is ground to within tolerances of -0 $+0{\cdot}001$in, and if required, it can be supplied specially to within tolerances of -0 $+0{\cdot}0005$in. It is available in lengths of 18in and diameters ranging from $\frac{1}{16}$in to 1in, and contains 0·95 per cent carbon, 1·70 per cent manganese, 0·25 per cent chromium and 0·25 per cent vanadium.

STORAGE BIN CLEANING TOOL.—A tool for use in removing dirt and dust from nuts, bolts, washers, screws, &c., stored in bins, has been produced by Martindale Electric Company, Ltd., of Westmorland Road, London, N.W.9. The tool can be connected by a suction attachment hose to any type of standard Martindale portable industrial blower. When the blower has been switched on the tool is held over the bin containing the parts to be cleaned and the parts are drawn up into a nose chamber where they are agitated to remove the dust and other dirt which they have collected. The dirt is drawn through a mesh screen, fitted in the top of the chamber, which ensures that no small parts are sucked through into the power unit. When a spring-operated lever at the top of the handle is depressed suction is stopped and the cleaned parts drop back into the container.

SYMPOSIUM ON THE TREATMENT OF WASTE WATERS. —The full programme is now available for the symposium on the treatment of waste waters, which is to be held at King's College, Newcastle upon Tyne, from September 14 to 19. The symposium is divided into three sections, dealing, respectively, with (*a*) the fundamentals of biological waste treatment, (*b*) practical applications of biological waste treatment, and (*c*) disposal of solids removed from liquid wastes. Twenty papers are listed in the programme, to cover these three subjects. One paper is a review of four contributions by Belgian authors. The symposium will also include visits to the refuse separation and composting plant at Edinburgh (described in THE ENGINEER of January 2 last), and the sewage purification works at Howick. Applications to attend the symposium should be made to the public health engineering section at King's College, Newcastle upon Tyne, 2.

TRANSFERRED CHARGE TELEPHONE SERVICE WITH RUSSIA.—Transferred charge calls between this country and the U.S.S.R. are to be a permanent feature of the telephone service between the two countries. For transferred charge calls from zone 1 of Russia, which includes Moscow, Leningrad and Kiev, the charges will be 34s. 6d. for three minutes, but for calls from telephone charge zones 2, 3 and 4 in the Soviet Union the charges will be the same as for calls in the opposite direction. There will be an additional charge on calls from all zones of the U.S.S.R., equal to one-third of the three minutes charge, to meet the greater cost of dealing with this type of call. If the person in this country declines to accept an incoming transferred charge call he will have no liability. Should the person called in the U.S.S.R. be unwilling to pay and the call be cancelled, the caller will be required to pay a supplementary fee to cover the cost of the attempt to connect the call.

MERCHANT SHIP GEARING.—At a meeting of The North-East Coast Institution of Engineers and Shipbuilders held on January 9 a paper entitled "High Torque Merchant Ship Gearing" was read, Part 1, "Design," by J. R. G. Braddyll, B.Sc., and Part 2, "Heat Treatment," by M. C. Oldham. The current trend in large tanker machinery is towards higher torques on the propeller shaft as deadweight is increased and the paper points out that although for reasons of cost and efficiency the retaining of the two-turbine single-screw arrangement is generally preferred, gearing differing from present practice may be desirable. Three proposals for gearing for machinery developing 26,500 h.p. at 109 r.p.m. are put forward and evaluated, and it is concluded that the use of hardened and ground gearing for the first-reduction units is advantageous preferably in conjunction with dual-tandem drive designed on "the non-vernier principle." The arrangement in the ship is briefly mentioned and some alternative relating to materials put forward, followed by a note upon economic considerations. Part 2 of the paper records details of the work done on surface hardening of gears for marine use with particular reference to : the equipment found suitable, the operation and procedure determined by experience, and the selection of the appropriate steel based upon the practical aspects of heat treatment taken in conjunction with fatigue properties. Some particulars are also given of alternative processes, including induction hardening and nitriding.

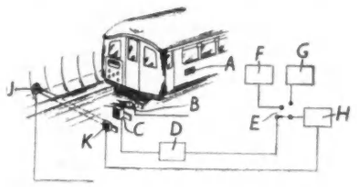
British Patent Specifications

When an invention is communicated from abroad the name and address of the communicator are printed in italics. When an abridgment is not illustrated the specification is without drawings, unless otherwise stated. The date first given is the date of application; the second date, at the end of the abridgment, is the date of publication of the complete specification. Copies of specifications may be obtained at the Patent Office Sales Branch, 15, Southampton Buildings, Chancery Lane, W.C.2, 3s. 6d. each.

RAILWAY ENGINEERING

809,464. March 14, 1956.—Apparatus for Recording the Passage of Vehicles, British Transport Commission, 55, Broadway, Westminster, London, S.W.1, and Robert Dell, 51, Eton Avenue, Sudbury.

This invention relates to apparatus for recording the passage of vehicles past a recording station, and has for its object to provide a recording apparatus producing automatically a record including a vehicle identification marking and a time marking. Referring to the drawing, on the side of the leading coach of the train at *A* is marked, in white figures on a black ground, an identification number. At the side of the track there is mounted a lamp *B* which illuminates the marking as the train passes, and a scanner *C* consisting of a vertical row of ten photo-electric cells,



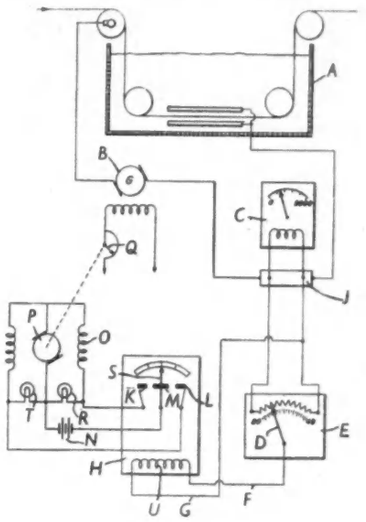
No. 809,464

is positioned so that light from the lamp is reflected on to it by the marking. The scanner is connected, through an amplifier unit *D* of any suitable type having separate amplifying means for signals from each of the photo-electric cells, to automatic switching means *E*. A train describer scanner *F* and a clock scanner *G* are also connected to the switching means, which is arranged to couple scanner *C*, *F* or *G* to a printing device *H*. Another lamp *J* is mounted on one side of the track and directs a beam of light on to a single photo-electric cell *K* on the other side of the track so that the beam is cut by an approaching train before the marking *A* comes into alignment with the scanner *C*, the cell being suitably coupled to switch means for starting up the printing device. The printing device first prints a facsimile of the marking *A* on the train and then operates the switching means to connect the train describer scanner and the clock scanner to itself in succession, so that records of the indication given by the train describer and the clock are also printed.—*February* 25, 1959.

STEELWORKS

809,341. July 13, 1956.—Current Density Control for Continuous Strip Processing Line, United States Steel Corporation, 525, William Penn Place, Pittsburgh 30, State of Pennsylvania, U.S.A.

This invention relates to a current density control device for a continuous strip processing line in which strips of different widths pass through an electrolyte having current supplied thereto. The control device is particularly suitable for processes in which the current density is of prime importance in obtaining suitable results while the speed of the strip is of minor importance. The drawing shows a schematic view of a strip processing line and control device. Current for the electrolytic treatment in tank *A* is supplied from a generator *B*. Assuming that a strip 48in wide is being processed between electrodes 48in long and that it is desired to maintain the current density at about 150A per square foot, the output from generator *B* must be 4800A. Under these conditions, if the shunt *J* is rated at 5000A, 0·05V, the potential drop across the terminals of the shunt will be 0·048V and ammeter *C* will indicate 4800A. Because the strip being processed is 48in wide, the arm *D* will be moved to the extreme right of the scale. The potentiometer *E* is so arranged that in this position there will be a potential of 0·0048V across wires *F* and *G*. The voltage is impressed upon field element *U* and causes meter *H* to indicate 150A per square foot. If a strip of different width is being processed, the arm is moved to that position on the scale and the meter will indicate the correct reading, it being understood that the output of the generator has been set to generate the required current for the desired current density. Assuming that the current density must be maintained between 140A and 160A per square foot, contacts *K* and *L* will be set so that the contact *M* will engage contact *K* when the meter reads 140A per square foot and will engage contact *L* when the meter reads 160A per square foot. When the current density falls to 140A per square foot and contacts *K* and *M* engage, current will flow from battery *N* through field *O* and armature *P* to rotate the motor so as to move arm *Q* in a direction to increase the output from the generator. The lamp *R* will also light up to indicate that the current density



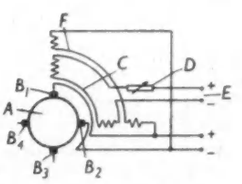
No. 809,341

is too low. As the output from the generator is increased, the pointer *S* moves up on the scale and causes contacts *M* and *K* to separate, which de-energises the motor so that it stops rotating. If the current density reaches 160A per square foot contacts *L* and *M* engage, thus completing a circuit from the battery through the armature and field. This causes the motor to operate in the opposite direction to decrease the output of the generator. At the same time a circuit is completed through lamp *T*, thus indicating that the current density is too high. When the output of the generator is decreased, the pointer moves down scale and causes contacts *M* and *L* to separate, which de-energises the motor to stop its rotation.—*February* 25, 1959.

ELECTRICAL GENERATORS

809,577. February 7, 1957.—Direct Current Generators with Independent External Circuits, Allmanna Svenska Elektriska Aktiebolaget, Västeras, Sweden.

The object of the present invention is to eliminate interference between the external circuits of a direct current generator with two or more independent circuits substantially independent of each other, such as may be used in devices which have to perform several separate movements by means of individual d.c. motors. Referring to the drawing, only the commutator *A* with the brushes B_1, B_2 and the excitation winding *C* of the corresponding pair of poles are shown, because all the pairs of poles are identically arranged. Each pair of poles is provided with the normal excitation winding which, in series with an adjustable resistor *D*, is connected at *E* to an



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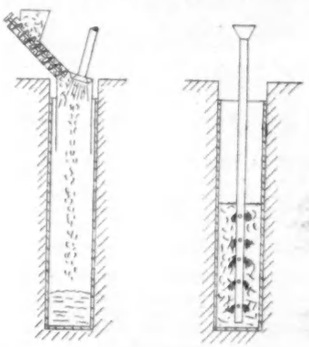
external voltage source. Winding *C* supplies the separate excitation for the pair of poles, the magnitude of which is determined by the resistor *D*, by means of which it is possible to adjust the voltage over the pair of brushes B_1, B_2. The pair of poles is further provided with a second excitation winding *F* which is connected to the voltage over the pair of brushes B_1, B_2 in such a way that the excitation from winding *F* counteracts the excitation from winding *C*. When the voltage over the pair of brushes B_1, B_2 increases, because of a change in the load in the other external circuit of the generator, the current through winding *F* also increases so that the increase in the voltage over the pair of brushes B_1, B_2 is counteracted. In the same way, the current through the winding *F* counteracts decreases in the voltage over the brushes caused by changes in the load in the other external circuits. When the separate excitation is entirely disconnected so that the current through the excitation winding *C* is zero, winding *F* keeps the voltage over the pair of brushes B_1, B_2 at zero, independent of the load current delivered from the other pair of brushes.—*February* 25, 1959.

MINING ENGINEERING

810,045. November 23, 1956.—Production of Blasting Charges in Vertical Bore-Holes, Imperial Chemical Industries, Ltd., Imperial Chemical House, Millbank, London, S.W.1. (*Inventors: James Edward Lambert and Idwal Owen Lewis.*)

The present invention is concerned with a new method and apparatus for producing blasting charges, and more particularly blasting explosive charges containing a substantial proportion of ammonium nitrate, in substantially vertical bore-holes. The method of producing a blasting charge comprises forming in the bore-hole an ammonium nitrate blasting explosive composition containing non-explosive organic liquid fuel by introducing separately into the bore-hole as loose solid particles the solid portion of the ammonium nitrate blasting explosive composition and, as liquid, the non-explosive organic liquid fuel portion. If the solid portion contains any solid ingredient additional to the ammonium nitrate, this is preferably non-explosive in character, and may be either mixed with the ammonium nitrate before or mixed with it during their introduction at a



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predetermined rate into the bore-hole. The latter procedure is preferable if the additional solid ingredient is of oxidisable character. Two embodiments of the invention are described with reference to the drawings. In the method shown in the left-hand drawing, the solid ingredients in loose particle form are metered from a hopper into a vertical tube by a screw conveyor. Concurrently the liquid portion of the explosive composition is delivered through a spraying device *A* fitted with a rose. In this manner the explosive composition is produced in the bore-hole, into which has been inserted a tube of waterproof material sealed at its lower end. In another form of apparatus of the invention, shown on the right, a perforated tube is inserted centrally in a vertical bore-hole lined with a tube of waterproofed material sealed at its lower end. The bore-hole is loaded with the solid portion of the explosive composition to a depth to cover the uppermost orifices. The liquid portion is then discharged through the orifices and distributed in the solid portion. Detonation of the explosive composition is initiated by a primer cartridge of, for example, a gelatine explosive positioned on the composition before earth is stemmed tightly into the bore-hole in the usual manner.—*March* 11, 1959.

CRAWLER TRACTORS

810,073. March 18, 1957.—Track-Tensioning for a "Crawler" Type Vehicle, International Harvester Company, 180, North Michigan Avenue, Chicago, 1, United States of America.

According to the invention, automatic track-tensioning means are provided for an endless track of a "crawler" type vehicle, in which an idler wheel unit is displaceable longitudinally. It includes a thrust member normally positioned to maintain a predetermined tension on the endless track and retractable against overload. The equipment described and illustrated in the specification comprises a hydraulic ram disposed between idler thrust member and the overload release means. A hydraulic accumulator communicating with the ram cylinder through a non-return valve permits transfer of fluid from the accumulator to the ram. There are means for maintaining a predetermined pressure in the accumulator, and consequently in the ram, for reacting on the thrust member to maintain a predetermined tension on the track.—*March* 11, 1959.

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of their insertion, the necessary information should reach this office not later than a fortnight before the meeting. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

ASSOCIATION OF SUPERVISING ELECTRICAL ENGINEERS

To-day, April 3.—BRISTOL AND WEST OF ENGLAND BRANCH: Royal York Hotel, Bath, "The Work of the National Inspection Council." 8 p.m. ★ LIVERPOOL AND DISTRICT BRANCH: Industrial Development Centre, M.A.N.W.E.B., Paradise Street, Liverpool, 1, "Revision of British Standards and the Effect on Electric Motor Performances," F. T. Bartho, 7.30 p.m.

Mon., April 6.—BOLTON BRANCH: Railway Hotel, Trinity Street, Bolton, "N.I.C.E.I.C.," H. F. Smith, 7.45 p.m. ★ LEEDS BRANCH: Great Northern Hotel, Leeds, Quiz Night, 7.30 p.m. ★ NORTH-EAST LONDON BRANCH: Angel Hotel, Ilford, Essex, "The Work of the National Inspection Council," E. J. Sutton, 8 p.m. ★ SHEFFIELD BRANCH: Royal Victoria Hotel, Sheffield, "Inland Waterways," 7.30 p.m.

Tues., April 7.—READING AND DISTRICT BRANCH: Electricity Board Demonstration Room, Market Square, Reading, "The A.S.E.E.," E. A. Bromfield, 7.15 p.m. ★ TYNESIDE BRANCH: Crown Hotel, Newcastle, "Education from the Turn of the Century," 7.30 p.m. ★ WEST KENT BRANCH: Visit to London Airport, 1.45 p.m. ★ WEST LONDON BRANCH: Windsor Castle Hotel, 134, King Street, Hammersmith, London, W.6, Lecturettes, 7.30 p.m.

Wed., April 8.—BIRMINGHAM BRANCH: Birmingham Exchange and Engineering Centre, Stephenson Place, Birmingham, 2, "Electrical Safety," G. L. Leighton, 7.30 p.m. ★ BRADFORD BRANCH: Midland Hotel, Bradford, "Wanderings with a Colour-film Camera," A. Spencer, 7.30 p.m. ★ GLASGOW BRANCH: Institution of Engineers and Shipbuilders in Scotland, 39, Elmbank Crescent, Glasgow, C.2, "Modern Techniques on Water Flow Measurements," W. H. P. Leslie, 8 p.m. ★ SOUTH EAST LONDON BRANCH: Eltham Green School, Queenscroft Road, Eltham, London, S.E.9, "Efficient Earth Leakage Protection," J. A. Robbins, 7.45 p.m.

Thurs., April 9.—SOUTH WEST LONDON BRANCH: Prince of Wales Hotel, Wimbledon, London, S.W.19, "Industrial Use of Isotopes," N. H. Lowden, 7.45 p.m.

Fri., April 10.—OXFORD AND DISTRICT BRANCH: Marlborough Club, Didcot, "Automatic Temperature Control," J. A. Taylor, 7.30 p.m.

BRITISH INSTITUTE OF MANAGEMENT

Tues., April 7.—LONDON STUDENTS AND GRADUATES SECTION: Fyvie Hall, 309, Regent Street, London, W.1, "Expanding Productivity," W. J. Carron and The Rt. Hon. Lord McCorquodale, P.C., 7 p.m. ★ PRODUCTION CONTROL STUDY GROUP: Management House, Fetter Lane, London, E.C.4, "Issue and Control of Work," L. E. Holton, 2.30 p.m.

BRITISH INSTITUTION OF RADIO ENGINEERS

Mon., April 6.—COMPUTER GROUP: London School of Hygiene and Tropical Medicine, Keppel Street, Gower Street, London, W.C.1, Symposium on "Large Capacity Storage Devices," 3 p.m. and 6 p.m.

Wed., April 8.—NORTH EASTERN SECTION: Institution of Mining and Mechanical Engineers, Neville Hall, Westgate Road, Newcastle upon Tyne, "Radio Exploration of the Galaxy," J. Baldwin, 6 p.m.

CHEMICAL SOCIETY

Wed., April 8.—Large Hall, Friends House, Euston Road, London, N.W.1, Annual General Meeting, 9.30 a.m.; Presidential Address: "Some Inorganic Polymers," H. J. Emeléus, 10.30 a.m.

ILLUMINATING ENGINEERING SOCIETY

Mon., April 6.—LEEDS CENTRE: Guildford Hotel, Leeds, Annual General Meeting, 6.15 p.m.

Thurs., April 9.—MANCHESTER CENTRE: Green Room Theatre, Cheapside, off Cross Street, Manchester, 2, Annual General Meeting: "*Son et Lumiere* in Great Britain," H. Hewitt, 6 p.m.

Mon., April 13.—SHEFFIELD CENTRE: Grand Hotel, Sheffield, Annual General Meeting: Technical Film Evening, 6.30 p.m.

INSTITUTE OF BRITISH FOUNDRYMEN

Thurs., April 9.—BEDS AND HERTS SECTION: K. and L. Steelfounders and Engineers, Ltd., Letchworth, Annual General Meeting; Film, 7.30 p.m.

INSTITUTE OF FUEL

Wed., April 8.—NORTH-WESTERN SECTION: Engineers' Club, Albert Square, Manchester, 2, Annual General Meeting, 2.15 p.m.

INSTITUTE OF MARINE ENGINEERS

Thurs., April 9.—WEST MIDLANDS SECTION: Birmingham Exchange and Engineering Centre, Stephenson Place, Birmingham, "Heavy Oil Burning," J. S. Clarke, and G. J. Hudson, 7 p.m.

INSTITUTE OF METALS

Tues., April 14.—Lecture Theatre, Royal Institution, Albemarle Street, London, W.1, "The Scientific Uses of Space Exploration," F. Hoyle, 7 p.m.

INSTITUTE OF PHYSICS

To-day, April 3, *and Sat., April* 4.—STRESS ANALYSIS GROUP: Technische Hogeschool, Delft, Netherlands, Delft Conference, in collaboration with the Instituut, T.N.O.

INSTITUTION OF BRITISH AGRICULTURAL ENGINEERS

Tues., April 14.—LONDON BRANCH: 6, Buckingham Gate, London, S.W.1, "The Measurement of Crop Drier Performance," P. H. Bailey, 2.15 p.m.

INSTITUTION OF CIVIL ENGINEERS

Tues., April 7.—Great George Street, Westminster, London, S.W.1, "Economics of Framed Structures," L. R. Creasy, 5.30 p.m.

Thurs., April 9.—MIDLANDS ASSOCIATION: James Watt Memorial Institute, Great Charles Street, Birmingham, 3, Lecture by W. Wood, 6 p.m.

INSTITUTION OF ELECTRICAL ENGINEERS

Mon., April 6.—INFORMAL MEETING: Savoy Place, London, W.C.2, Discussion on "Co-operation between the Electricity and Gas Industries," opened by F. C. Smith, 5.30 p.m. ★ MERSEY AND NORTH WALES CENTRE: Royal Institution, Colquitt Street, Liverpool, Annual General Meeting, "Artificial Fibres," P. T. Standring, 6.30 p.m. ★ NORTH-EASTERN RADIO AND MEASUREMENT GROUP: College of Technology, Rutherford, Annual General Meeting, Films, 6.15 p.m. ★ SOUTH MIDLAND CENTRE: College of Technology, Gosta Green, Birmingham, Joint Meeting with the South Midland Supply and Utilization Group; "The Provision of Adequate Electrical Installation in: (*a*) Multi-Storey Flats and Maisonettes," C. A. Belcher, "(*b*) Houses," C. C. Hyams, 6 p.m.

Tues., April 7.—EAST MIDLAND CENTRE: College of Arts and Crafts, Nottingham, "Subscriber Trunk Dialling," D. A. Barron, 6.30 p.m. ★ MEASUREMENT AND CONTROL SECTION: Savoy Place, London, W.C.2, "An Electron Trajectory Tracer for Use with the Resistance Network Analogue," M. E. Haine and J. Uine, 5.30 p.m. ★ NORTH MIDLAND CENTRE: Royal Station Hotel, York, "The Relation between Picture Size, Viewing Distance and Picture Quality," L. C. Jesty, 7 p.m. ★ NORTH WESTERN CENTRE: Engineers' Club, 17, Albert Square, Manchester, "H.V. D.C. Transmission, with Special Reference to the Cross Channel Cable," F. J. Lane, 6.15 p.m.

Wed., April 8.—RADIO AND TELECOMMUNICATION SECTION: Savoy Place, London, W.C.2, "The New Post Office 700-Type Telephone," F. E. Williams and F. C. Carter, "The Design of an Automatic Sensitivity Control for a New Subscriber's Telephone Set—The British Post Office 700-Type Telephone," F. E. Williams and F. A. Wilson, 5.30 p.m. ★ NORTH LANCASHIRE SUB-CENTRE: North-Western Electricity Board Lecture Theatre, Jubilee Street, Blackburn, "Thermonuclear Processes with Special Reference to ZETA," E. R. Hartill, 7.15 p.m. ★ SOUTH-WEST SCOTLAND SUB-CENTRE: Institution of Engineers and Shipbuilders, 39, Elmbank Crescent, Glasgow, C.2, "Investigations of Power Follow-Current Phenomena Using a Synthetic Power Source," L. L. Alston and F. M. Bruce, 7 p.m. ★ SOUTHERN CENTRE: S.E.B. Canteen, Drayton, Portsmouth, Annual General Meeting; "Rockets and Satellites," R. L. F. Boyd, 6.30 p.m.

Thurs., April 9.—NORTH MIDLAND CENTRE: Yorkshire Electricity Board Offices, Ferensway, Hull, "Electrical Installations of the R.A.E. High-Speed Wind Tunnel at Bedford," P. McKearney, L. S. Drake and E. G. Mallalieu, 6.30 p.m. ★ WEST WALES (SWANSEA) SUB-CENTRE: Conference Room, S.W.E.B. Showrooms, The Kingsway, Swansea, "Domestic High-Fidelity Reproduction," J. Moir, 6 p.m.

Fri., April 10.—MEDICAL ELECTRONICS DISCUSSION GROUP: Savoy Place, London, W.C.2, Discussion on "Problems of Sight, Hearing and Touch," opened by E. C. Cherry, and "Human Engineering Recording Problems," opened by H. C. W. Stockbridge, 6 p.m. ★ SOUTHERN CENTRE: South Dorset Technical College, Weymouth, "Thermonuclear Reactors," D. W. Fry, 6.30 p.m.

Sat., April 11.—LONDON GRADUATE AND STUDENT SECTION: Visit to S.S. "Orsova," Tilbury Docks, 2.30 p.m.

Mon., April 13.—EDUCATION DISCUSSION CIRCLE: Savoy Place, London, W.C.2, Discussion on "The Function and Content of an Electric Theory Course," opened by F. E. Rogers, 6 p.m. ★ NORTH-EASTERN CENTRE: Royal Station Hotel, Newcastle upon Tyne, Annual General Meeting and Conversazione, 6.15 p.m. ★ WESTERN CENTRE: St. Mary's College, Cheltenham, "Transistors in Communication and Control Equipment—A General Survey," E. Wolfendale, 6 p.m.

INSTITUTION OF ENGINEERING DESIGNERS

Mon., April 13.—NORTH-EAST BRANCH: Northern Architectural Association Hall, 6, Higham Place, Newcastle upon Tyne, 1, "Plastics and the Engineer," W. J. Grant, 7.15 p.m.

INSTITUTION OF ENGINEERS AND SHIPBUILDERS IN SCOTLAND

Tues., April 7.—39, Elmbank Crescent, Glasgow, "Engineering Aspects of 25kV Overhead A.C. Railway Electrification," A. Watt, 6.30 p.m.

INSTITUTION OF HIGHWAY ENGINEERS

To-day, April 3.—LONDON BRANCH: Institution of Structural Engineers, 11, Upper Belgrave Street, London, S.W.1, "Some of the Technical and Administrative Problems Arising on Motorways in Great Britain," J. D. W. Jeffery, 5.30 p.m.

INSTITUTION OF LOCOMOTIVE ENGINEERS

Wed., April 15.—Institution of Mechanical Engineers, 1, Birdcage Walk, Westminster, London, S.W.1, "Vehicle Suspension and Bogie Design in Relation to Track Conditions," R. M. Hancock, 5.30 p.m.

INSTITUTION OF MECHANICAL ENGINEERS

To-day, April 3.—1, Birdcage Walk, Westminster, London, S.W.1, Technical Film Show, 6 p.m.

Tues., April 7.—LEONARDO DA VINCI LECTURE FOR SCHOOLBOYS AND SCHOOLGIRLS: 1, Birdcage Walk, Westminster, London, S.W.1, "Transport On and Under the Sea," W. A. Crago and E. Norton, 10 a.m. and 2.45 p.m. ★ SOUTH WALES BRANCH: Kingsway Demonstration Theatre, S. Wales Electricity Board, Swansea, "Manufacture of Small Steel Castings by New Moulding Techniques," C. B. Carter, 6 p.m. ★ NORTH WESTERN A.D. CENTRE: Leyland Motors, Ltd., Leyland, Lancs, "Standards and Standardization in the Motor Industry," E. F. Woodbridge, 7.15 p.m.

Wed., April 8.—INTERNAL COMBUSTION ENGINE GROUP: 1, Birdcage Walk, Westminster, London, S.W.1, Discussion on "What is the Present Position of the Gas Turbine Relative to the Diesel Engine for Satisfactory Stationary, Marine and Automobile Applications?" 6 p.m. ★ EAST MIDLANDS BRANCH: Technical College, Lincoln, "Modern Aids in the Design of Railway Bogies," A. W. Manser, 7.15 p.m. ★ EASTERN GRADUATES' SECTION: Visit to Cambridge University Engineering Laboratories, 2.30 p.m. ★ YORKSHIRE GRADUATES' SECTION: Visit to Hope and Anchor Breweries, Ltd., Claywheels Lane, Sheffield, 7 p.m.

Fri., April 10.—JAMES CLAYTON LECTURE: 1, Birdcage Walk, Westminster, London, S.W.1, "Some Highlights of Experience and Engineering of High-Power Heavy-Water-Moderated Nuclear Reactors," W. B. Lewis, 6 p.m.

Tues., April 14.—AUTOMOBILE DIVISION: 1, Birdcage Walk, Westminster, London, S.W.1, "The Performance of Vehicles under Trans-Antarctic Conditions," D. L. Pratt, 6 p.m. ★ EASTERN GRADUATES' SECTION: Crown and Anchor Hotel, Ipswich, "The Graduate—His Future," J. B. Webster, 7.30 p.m.

INSTITUTION OF PRODUCTION ENGINEERS

Tues., April 7.—BIRMINGHAM GRADUATE SECTION: Visit to Round Oaks Steel Works, Brierly Hill, Worcestershire, 7 p.m. ★ LIVERPOOL GRADUATE SECTION: Radiant House, Bold Street, Liverpool, 1, "Mistakes," E. Walshaw, 7.30 p.m.

Wed., April 8.—MIDLANDS REGION: Wolverhampton and Staffs College of Technology, Wolverhampton, "Materials Handling," L. J. Hoefkens, 7.15 p.m. ★ NORTH WESTERN REGION: Accrington College of Further Education, Sandy Lane, Accrington, "Handling and Packaging for Export," S. C. Owen; Film, "Handling With Care," 7.30 p.m. ★ SOUTH WESTERN REGION: Bristol Aircraft, Ltd., Old Mixcon, Film Show, 7.30 p.m.

Thurs., April 9.—NORTHERN IRELAND REGION: Kensington Hotel, College Square East, Belfast, "Application of Modern Production Control Techniques," T. W. Price, 7.30 p.m.

Sat., April 11.—WOLVERHAMPTON GRADUATE SECTION: Morning visit to Rover Company, Ltd., Solihull, Warwicks. ★ SOUTH EASTERN REGION: Half-day visit to Arthur Guinness Son and Co. (Park Royal), Ltd., 10 a.m.

JUNIOR INSTITUTION OF ENGINEERS

To-day, April 3.—Pepys House, 14, Rochester Row, Westminster, London, S.W.1, Films: "Great Day," "More Power from the Atom," "Radioisotopes in Industry," and "Metals of the Nuclear Age," 7 p.m.

Fri., April 10.—ORDINARY MEETING: Pepys House, 14, Rochester Row, Westminster, London, S.W.1, "Radiography and its Application to Arc Welded Joints," R. F. Wilks.

LIVERPOOL METALLURGICAL SOCIETY

Thurs., April 9.—Library, Department of Metallurgy, The University, 146, Brownlow Hill, Liverpool, 3, "Boron in Steel," F. B. Pickering, Annual General Meeting, 7 p.m.

MANCHESTER GEOLOGICAL AND MINING SOCIETY

Thurs., April 9.—Wigan and District Mining and Technical College, Wigan, "Research on Industrial Relations," W. H. Scott, 3.15 p.m.

MANCHESTER STATISTICAL SOCIETY

To-day, April 3.—INDUSTRIAL GROUP: Portico Library, 57, Mosley Street, Manchester, "Recent Developments in the Measurement of Productivity in the Textile Industry," L. H. C. Tippett, 6 p.m.

NEWCOMEN SOCIETY

Wed., April 8.—Science Museum, South Kensington, London, S.W.7, "Drive to Stones in Windmills," Rex Wailes; "Danish Windmills," Anders K. Jesperson, 5.30 p.m.

NORTH EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS

To-day, April 3.—Lecture Theatre, Mining Institute, Newcastle upon Tyne, "Resistance and Propulsion of Trawlers," D. J. Doust and T. P. O'Brien, 6.15 p.m.

Fri., April 17.—Mining Institute, Newcastle upon Tyne, "Some Shipowners' Problems," R. Munton, 6.15 p.m.

OLD CENTRALIANS

Mon., April 13.—Room No. 15, City and Guilds College, Exhibition Road, London, S.W.7, Annual General Meeting, 5.30 p.m.

PHYSICAL SOCIETY

Wed. to Fri., April 8 *to* 10.—The University, Oxford, Conference on Nuclear Physics.

PLASTICS INSTITUTE

To-day, April 3.—NORTH-WESTERN SECTION: Textile Institute, Blackfriars Street, Manchester, "Developments in the Processing and Application of Acrylic Resins," L. Griffiths, 6.45 p.m.

Wed., April 8.—SOUTH WALES AND MONMOUTHSHIRE SECTION: Angel Hotel, Westgate Street, Cardiff, "Newer Processes for Treatment of P.V.C.," I. Phillips, 6.30 p.m.

RAILWAY DEVELOPMENT ASSOCIATION

Tues., April 14.—Tudor Room, Caxton Hall, Westminster, London, S.W.1, Discussion in association with the Railway Conversion League, "Railways into Roadways," 7.30 p.m.

REINFORCED CONCRETE ASSOCIATION

Tues., April 14.—MIDLAND COUNTIES BRANCH: Birmingham and Midland Institute, Paradise Street, Birmingham, "The Use of Lightweight Concrete for Reinforced Concrete Structures," A. Short, 6 p.m.

ROYAL SOCIETY OF ARTS

Thurs., April 16.—John Adam Street, Adelphi, London, W.C.2, "Britain and the Technical Development of Eastern Commonwealth Countries under the Colombo Plan," W. Railston, 5.15 p.m.

SOCIETY OF CHEMICAL INDUSTRY

To-day, April 3.—Robinson Lecture Theatre, Manchester University, Oxford Road, Manchester, 13, "Titanium and its Alloys as Materials of Construction for Chemical Plant," K. W. J. Bowen, 6.30 p.m.

Tues., April 14.—CORROSION GROUP: 14, Belgrave Square, London, S.W.1, Spring Lecture, "Studies of the Influence of Chemical Factors on the Corrosion of Metals," W. Feitknecht, 6.30 p.m.

SOCIETY OF ENGINEERS

Mon., April 6.—Geological Society, Burlington House, Piccadilly, London, W.1, "Sonics," G. Constantinesco, 5 p.m.

UNIVERSITY COLLEGE LONDON

Wed., April 15.—Gower Street, London, W.C.1, "The Work of Coker and Filon on Photo-elasticity," H. T. Jessop, 6 p.m.

UNIVERSITY OF LIVERPOOL

Sun. to Sat., April 5 *to* 11.—Derby Hall, Liverpool, Easter Conference on Mathematics.

WEST OF SCOTLAND IRON AND STEEL INSTITUTE

Fri., April 10.—39, Elmbank Crescent, Glasgow, Symposium on "Open-Hearth Furnace Maintenance," 6.45 p.m.

Advanced Engineering Courses

Nuclear Reactor Technology. DEPARTMENTS OF ELECTRICAL ENGINEERING AND PHYSICS, Institute of Technology, Bradford. A six weeks' course, presenting in some detail the basic principles of the physics and engineering of nuclear power reactors to those interested or engaged in this field. Monday, April 20, to Friday, May 29. Fee £30.

Production Planning and Control. INSTITUTE FOR ENGINEERING PRODUCTION, "Southfield," 16, Norfolk Road, Edgbaston, Birmingham, 15. This course is intended for industrial executives, senior production engineers and controllers, O. and M. personnel and other specialists in related fields. Methods of production planning and control will be discussed. Monday, April 20, to Friday, May 1. Fee 55 guineas.

Mechanical Vibrations. NOTTINGHAM AND DISTRICT TECHNICAL COLLEGE, Burton Street, Nottingham. A post-graduate course of twelve lectures to be held on Friday evenings, commencing April 10, 6.45 p.m. Fee 11s.

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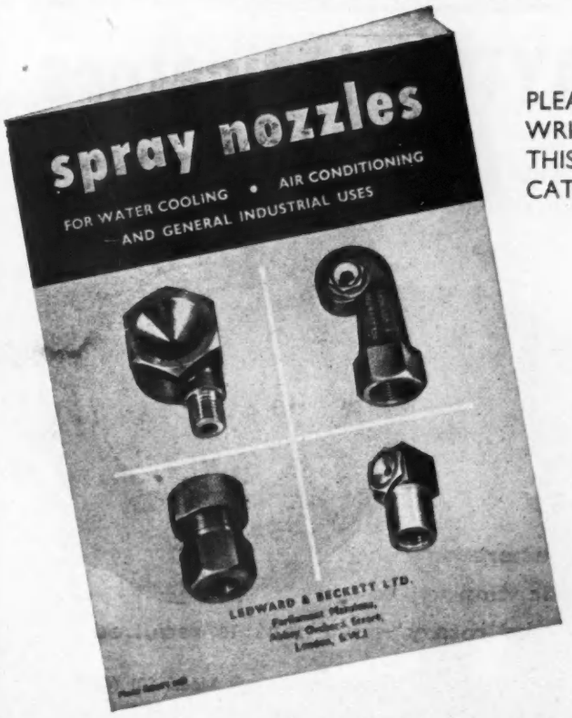

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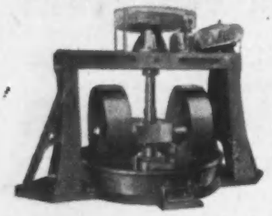

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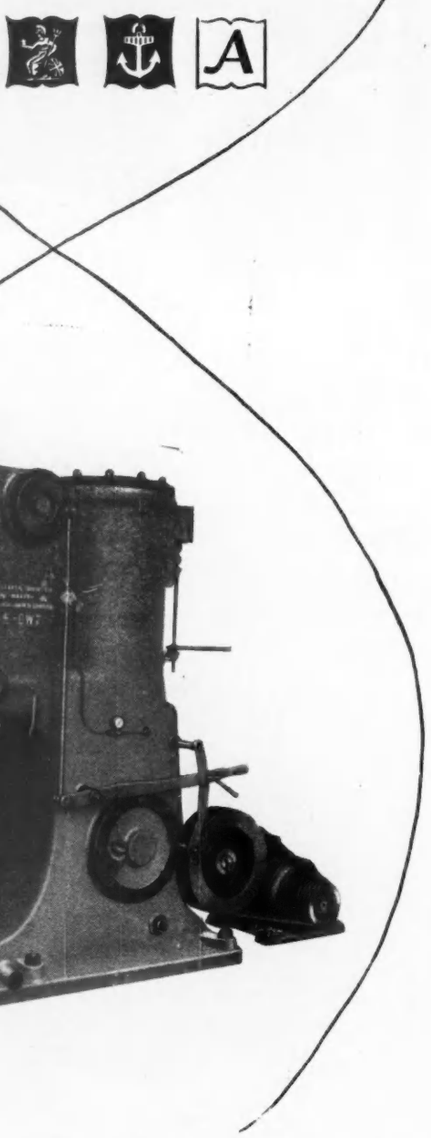

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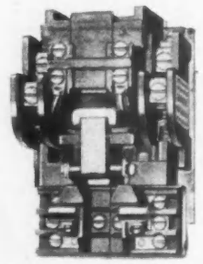

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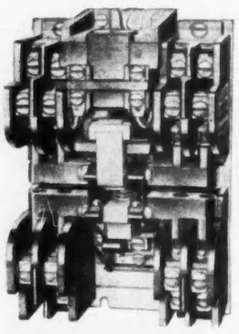

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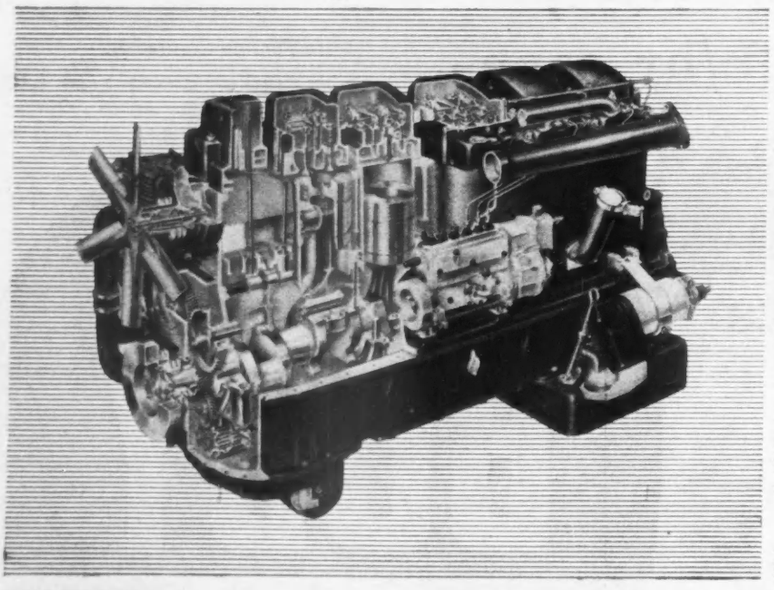

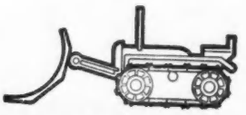

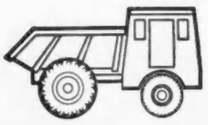

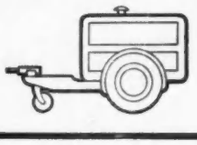

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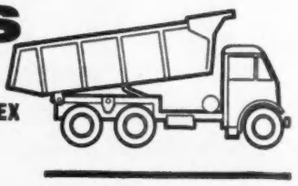

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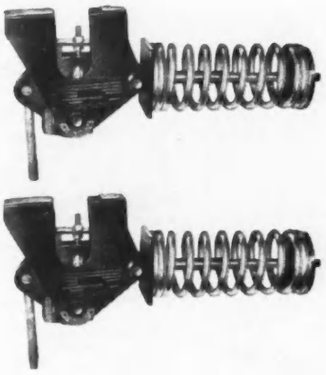

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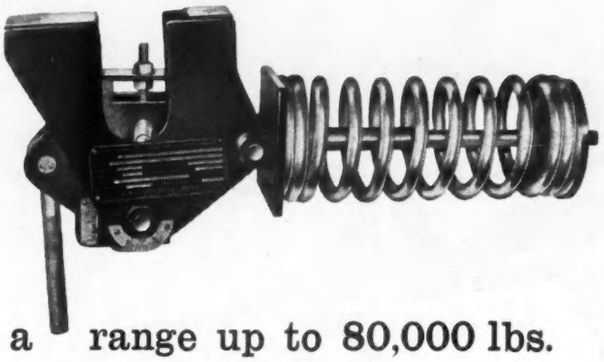

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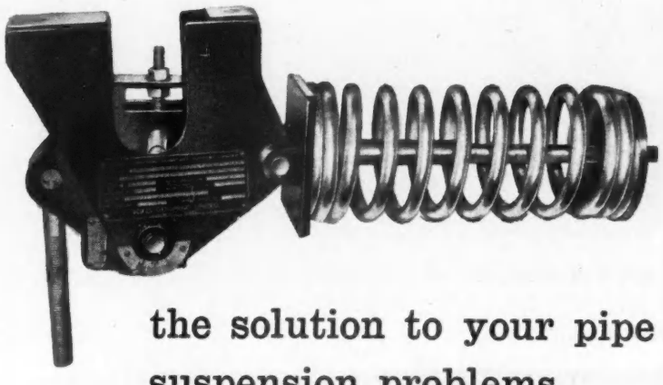

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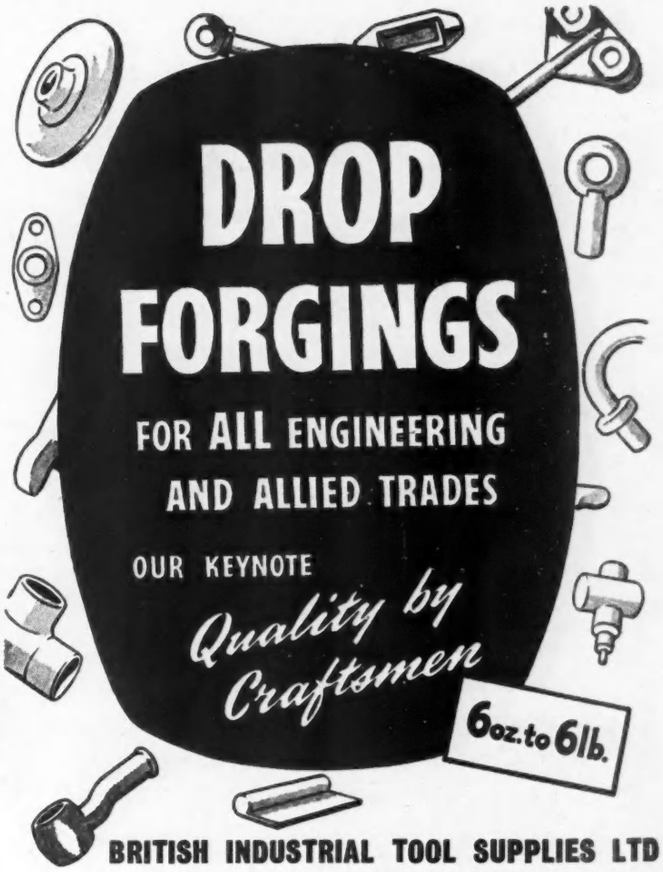

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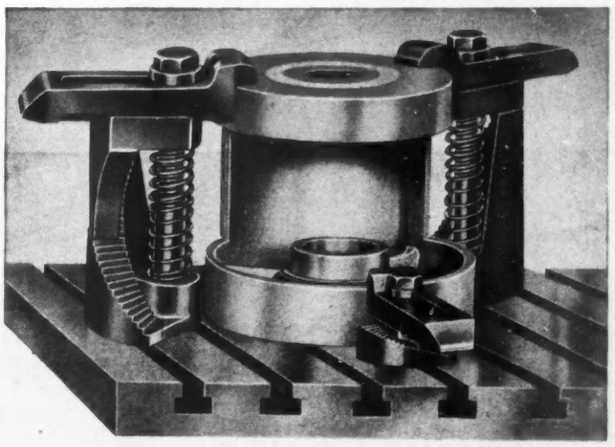

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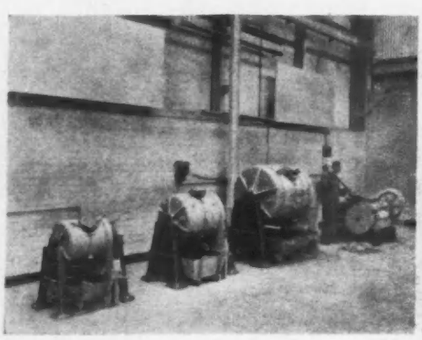

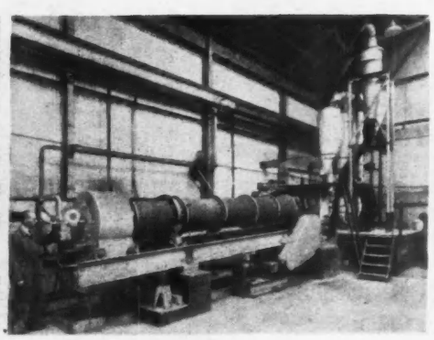

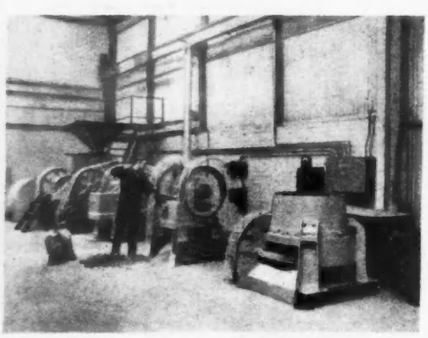

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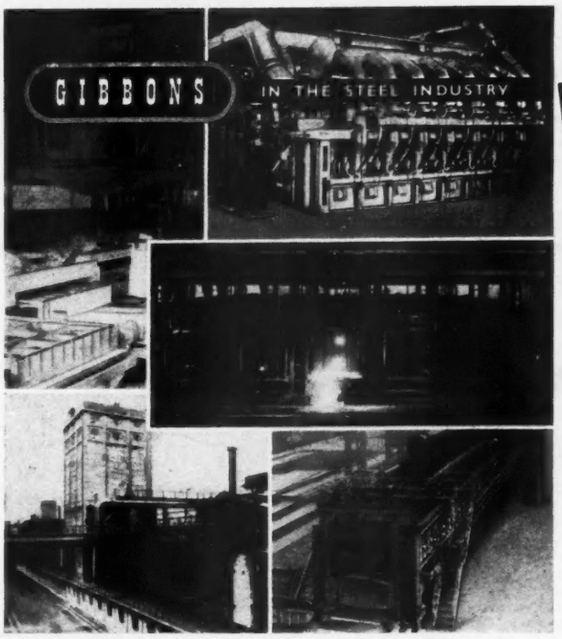

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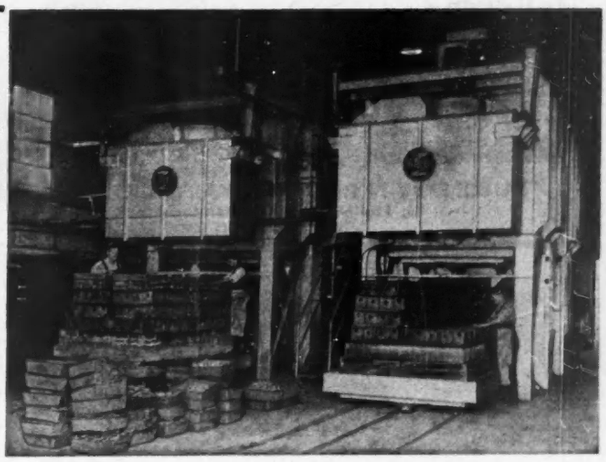

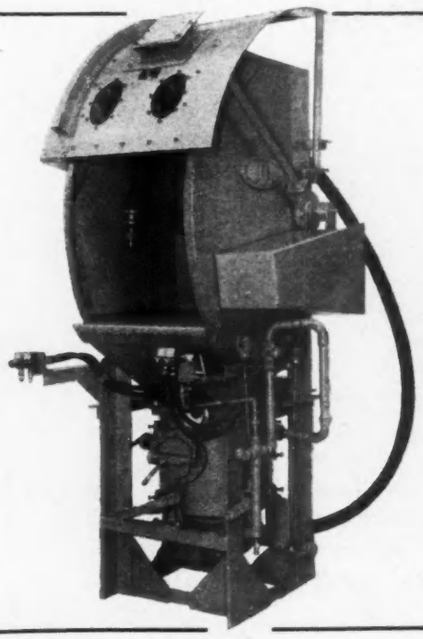

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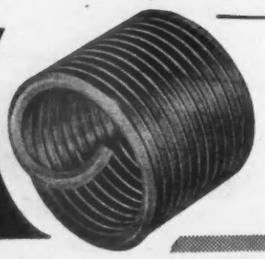

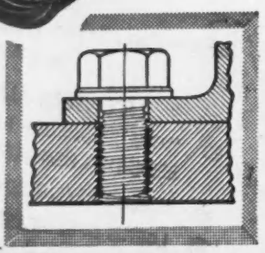

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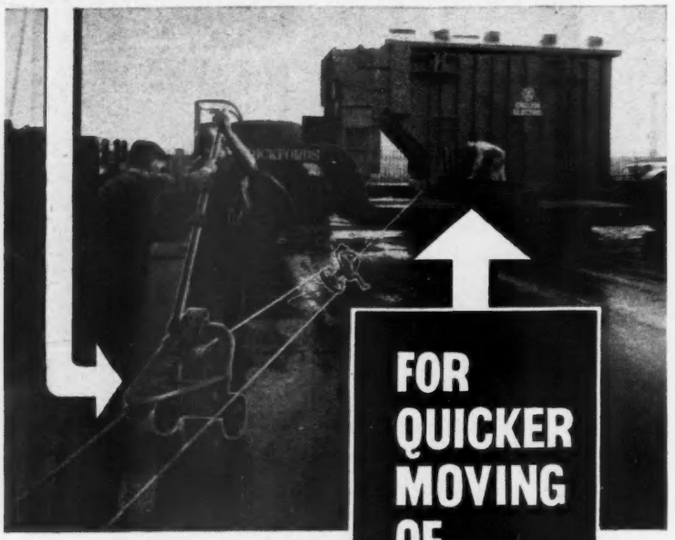

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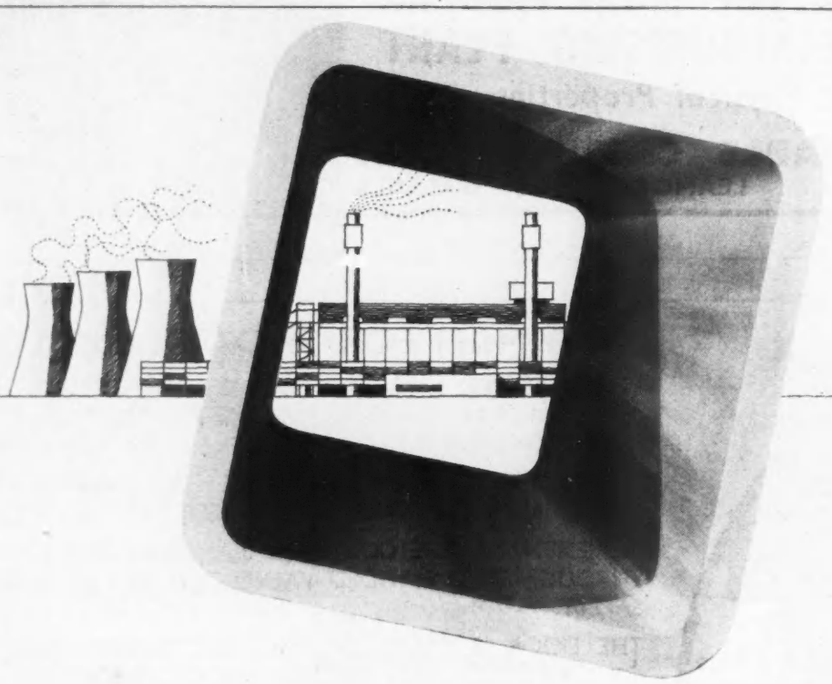

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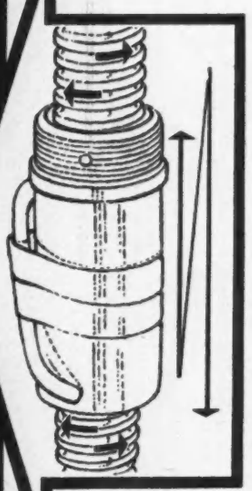

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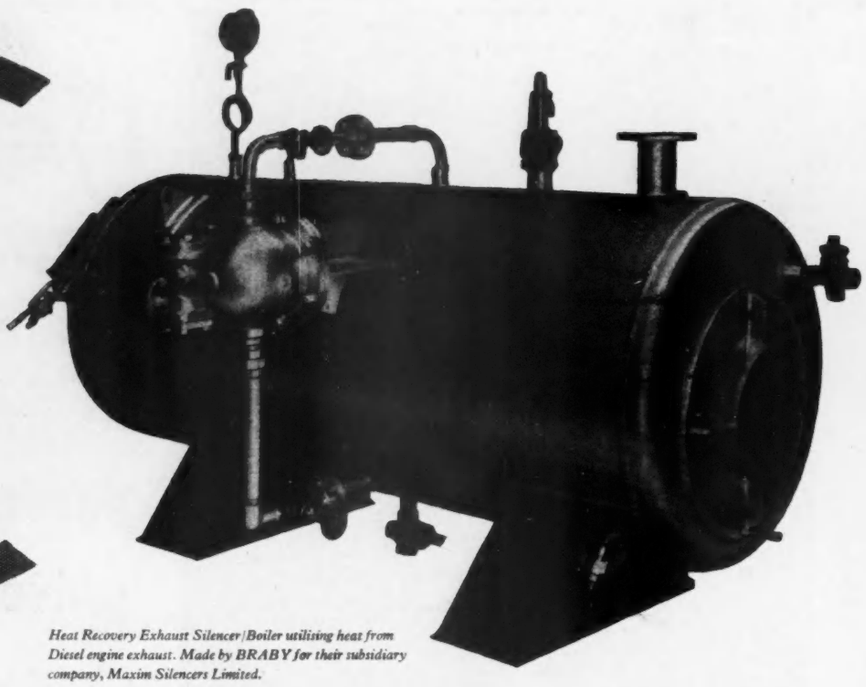

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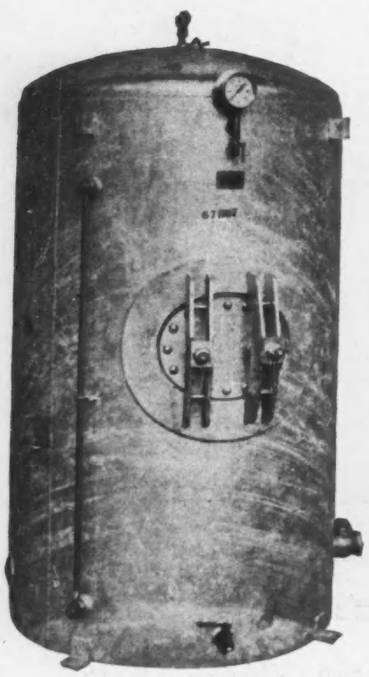

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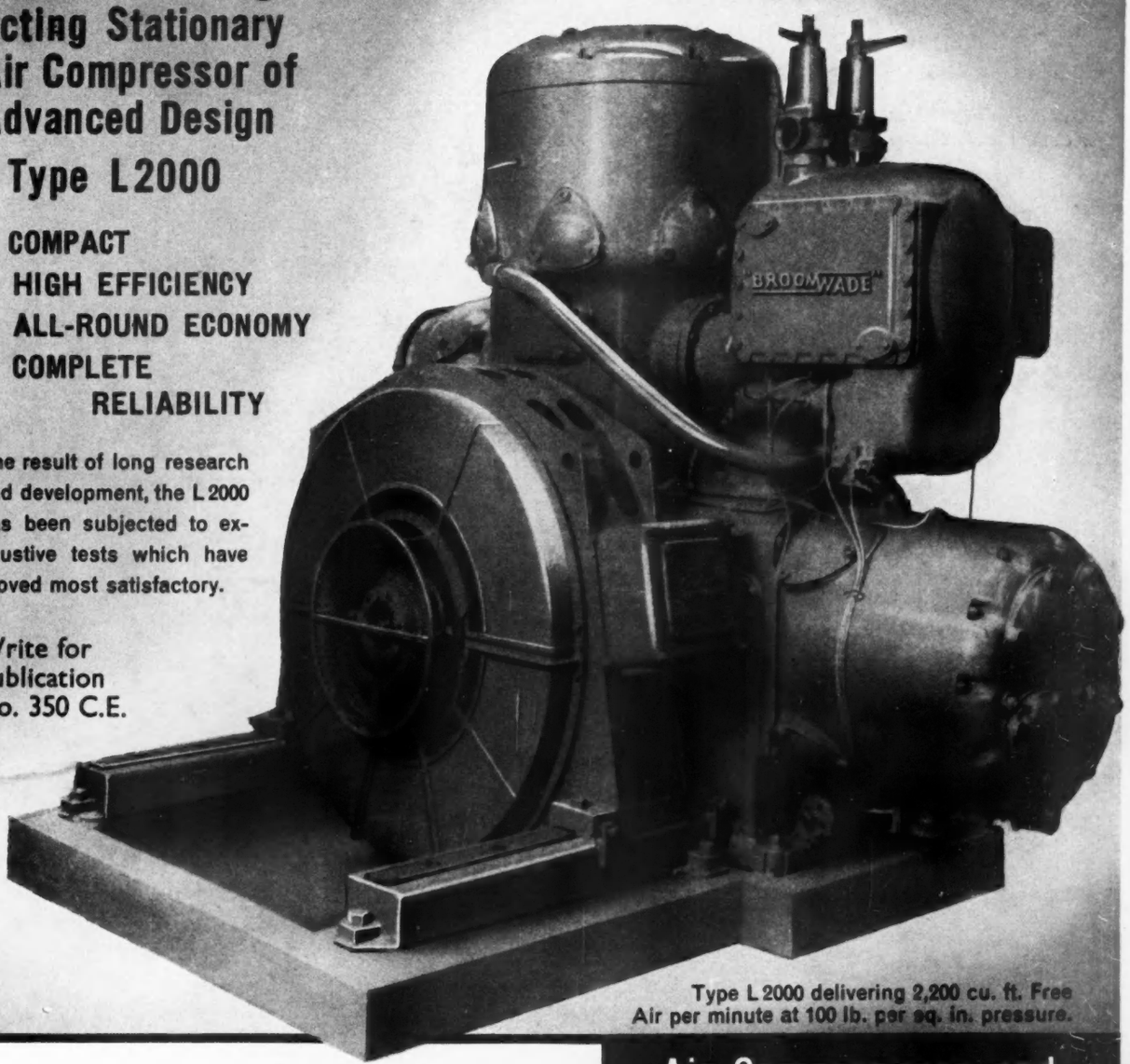

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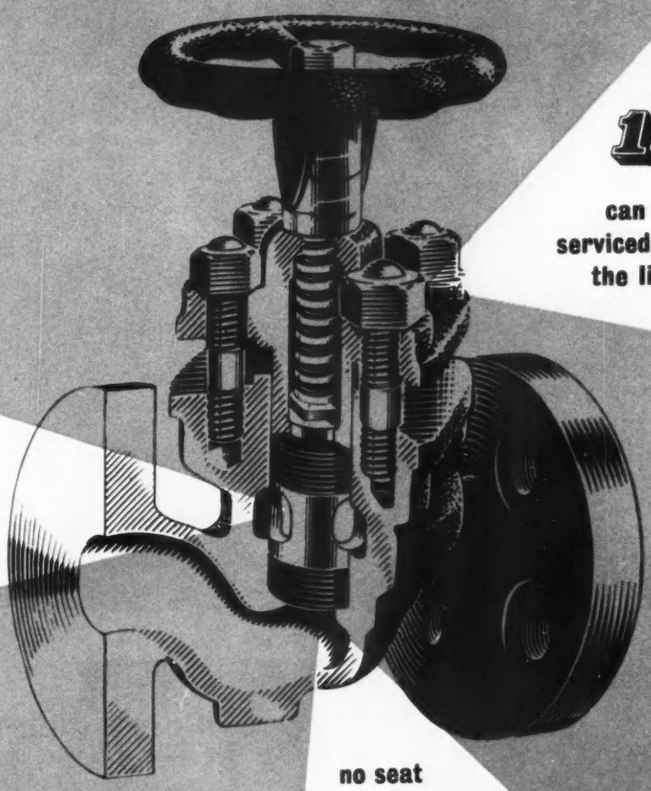

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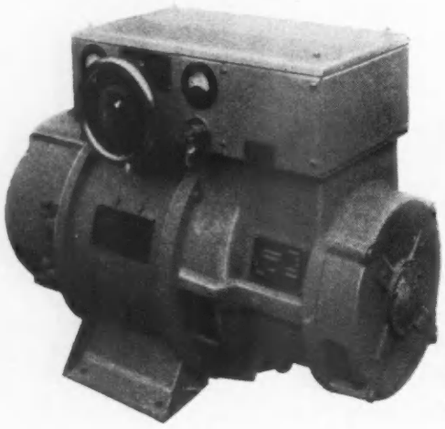

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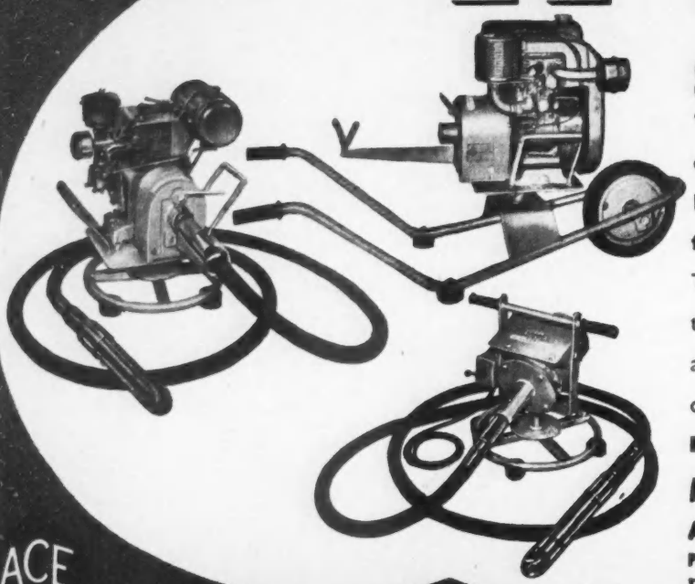

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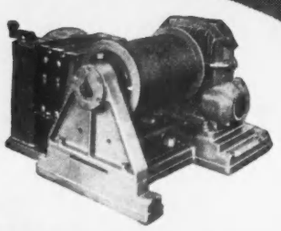

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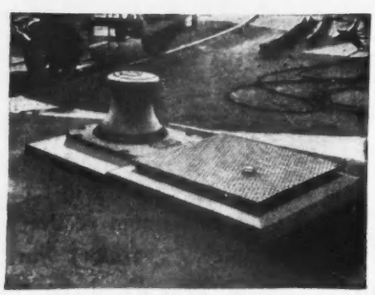

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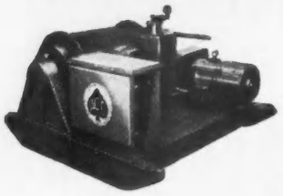

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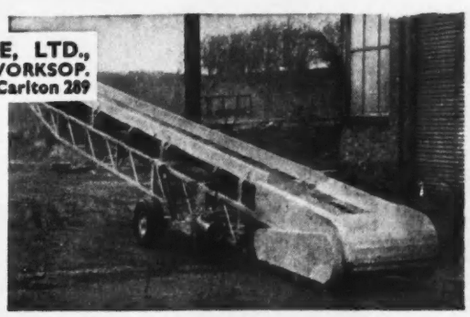

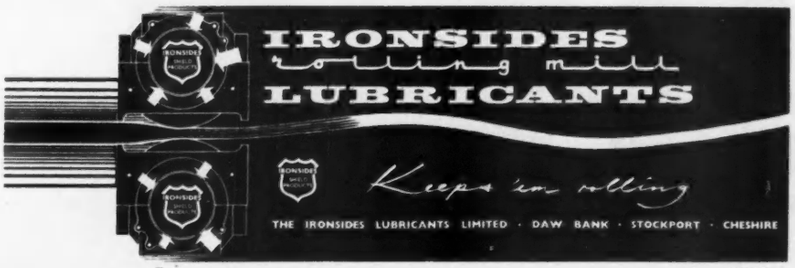

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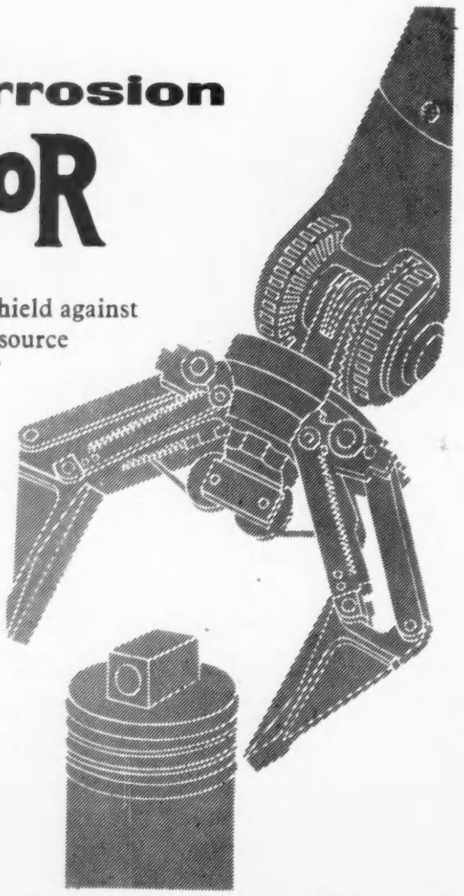

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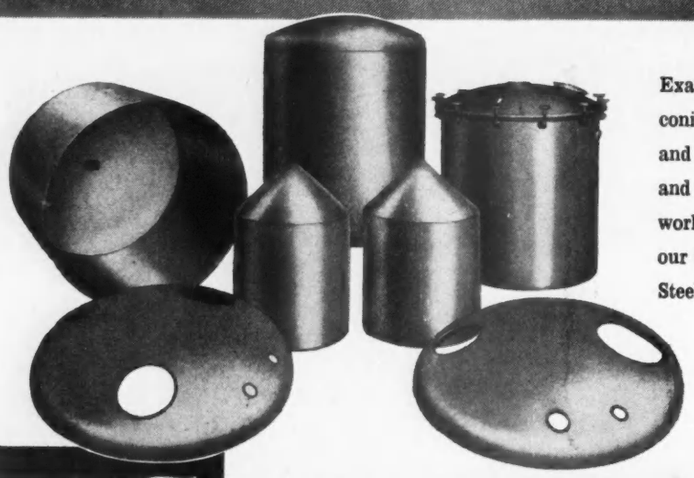

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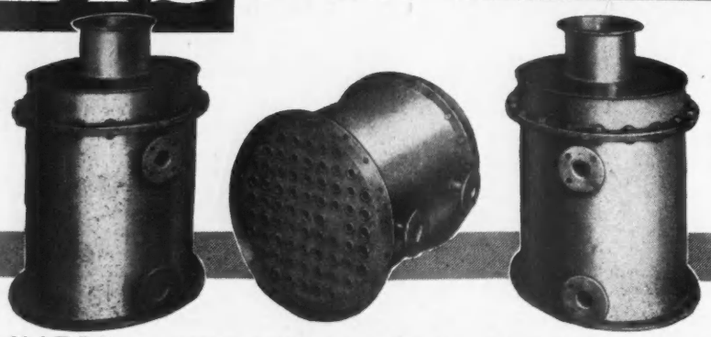

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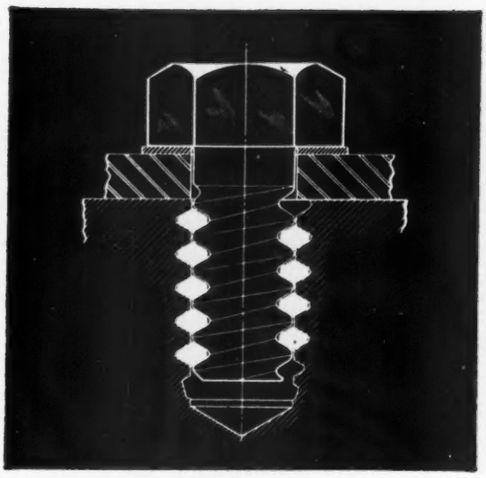

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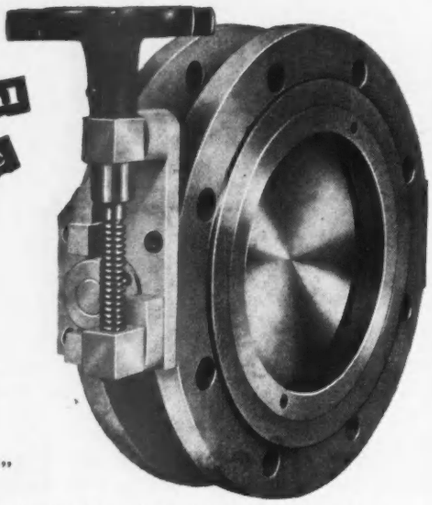

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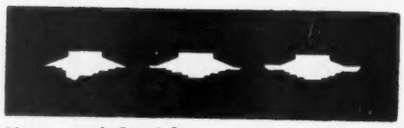
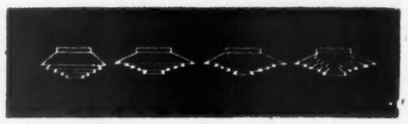


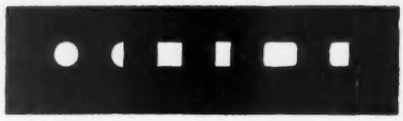
Main types, A, B and C.

4



Variations, High level, Low level, etc.

6



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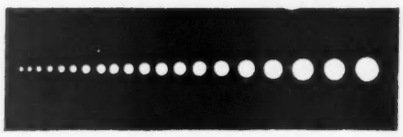

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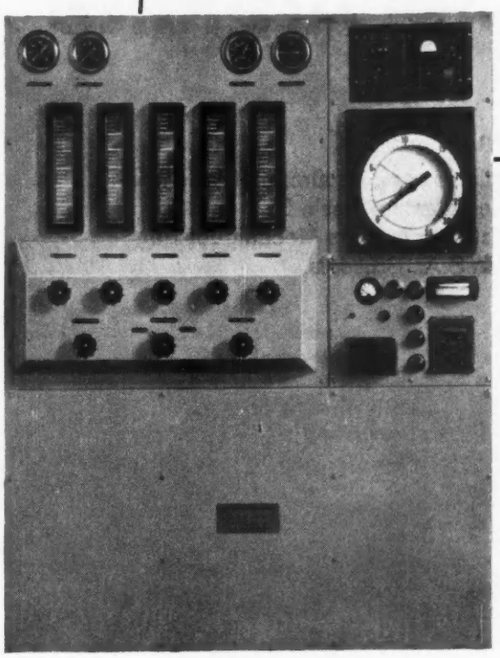

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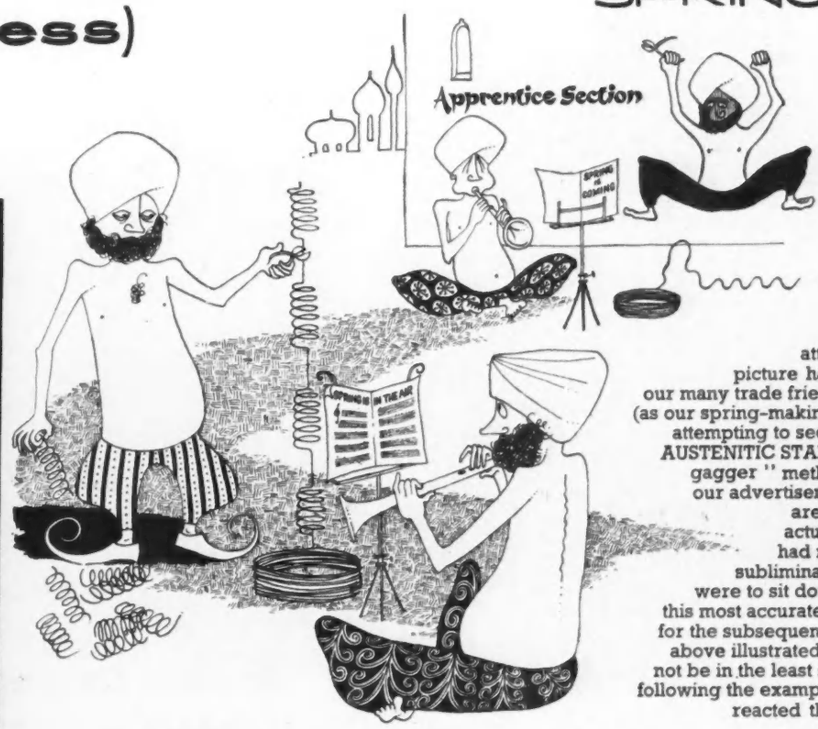

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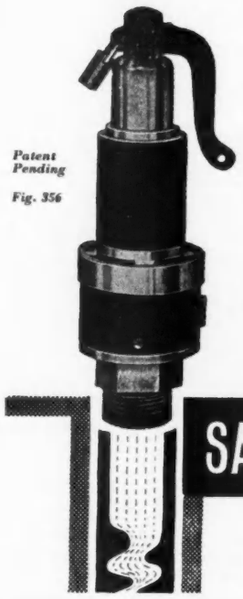

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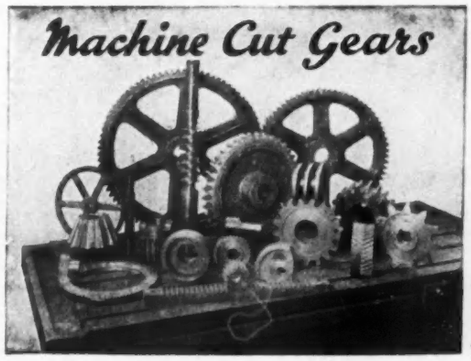

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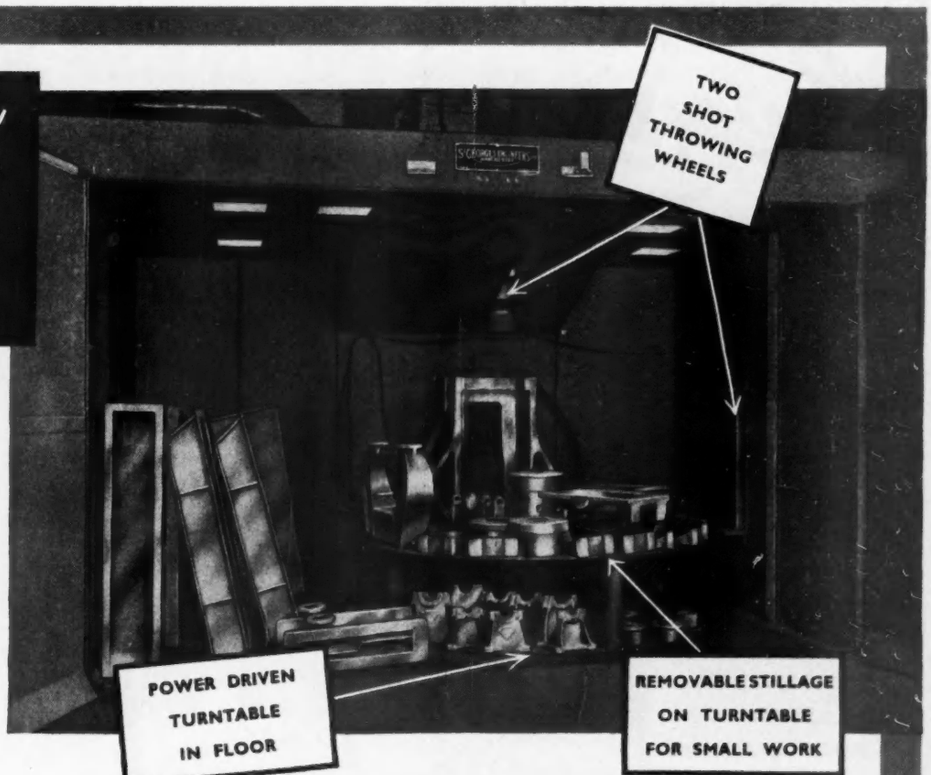

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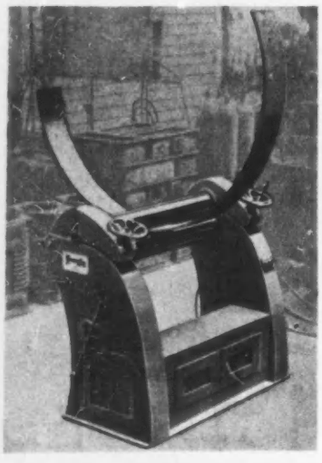

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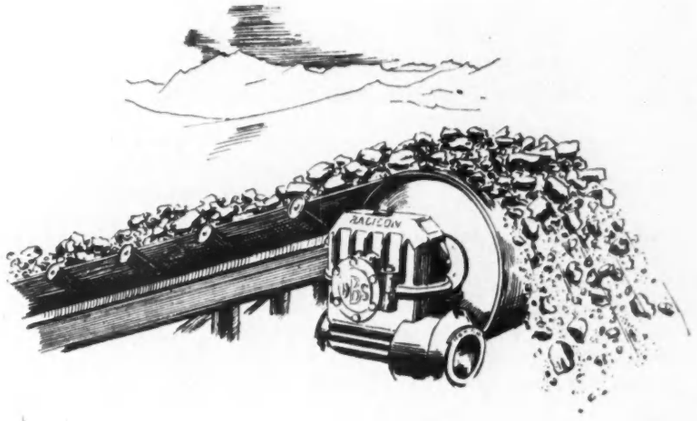

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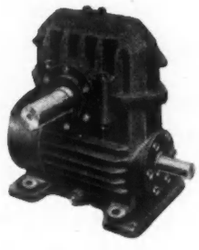

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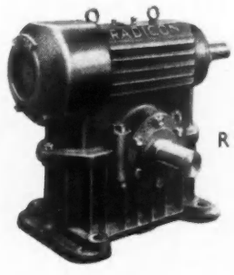

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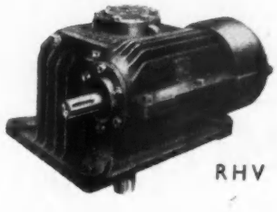

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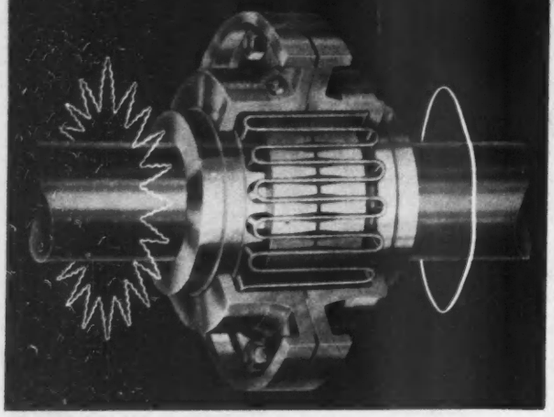

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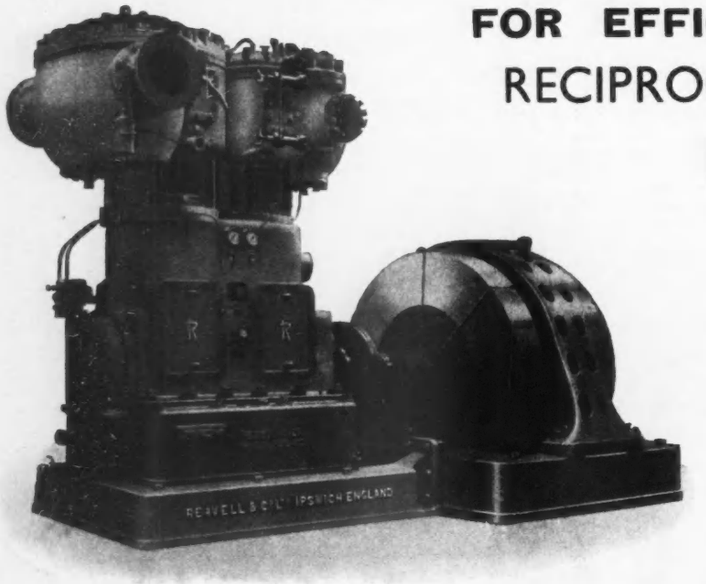

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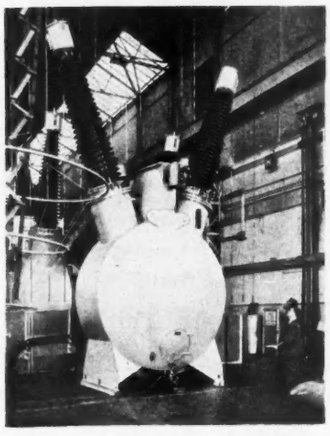

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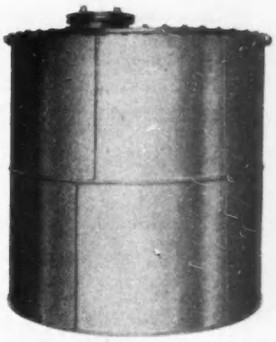

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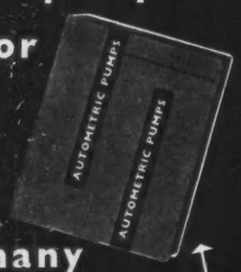

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Fuel tanks, elevators, tail planes, pressings, fabrications in all metals.

Our Sheet Metal Working Plant includes:
Presses up to 200 tons, Guillotines, Wiring Machines, Press Brakes, Benders, Riveting and all types of Welding and General Engineering Plant.

E. G. Brown & Co., Ltd.

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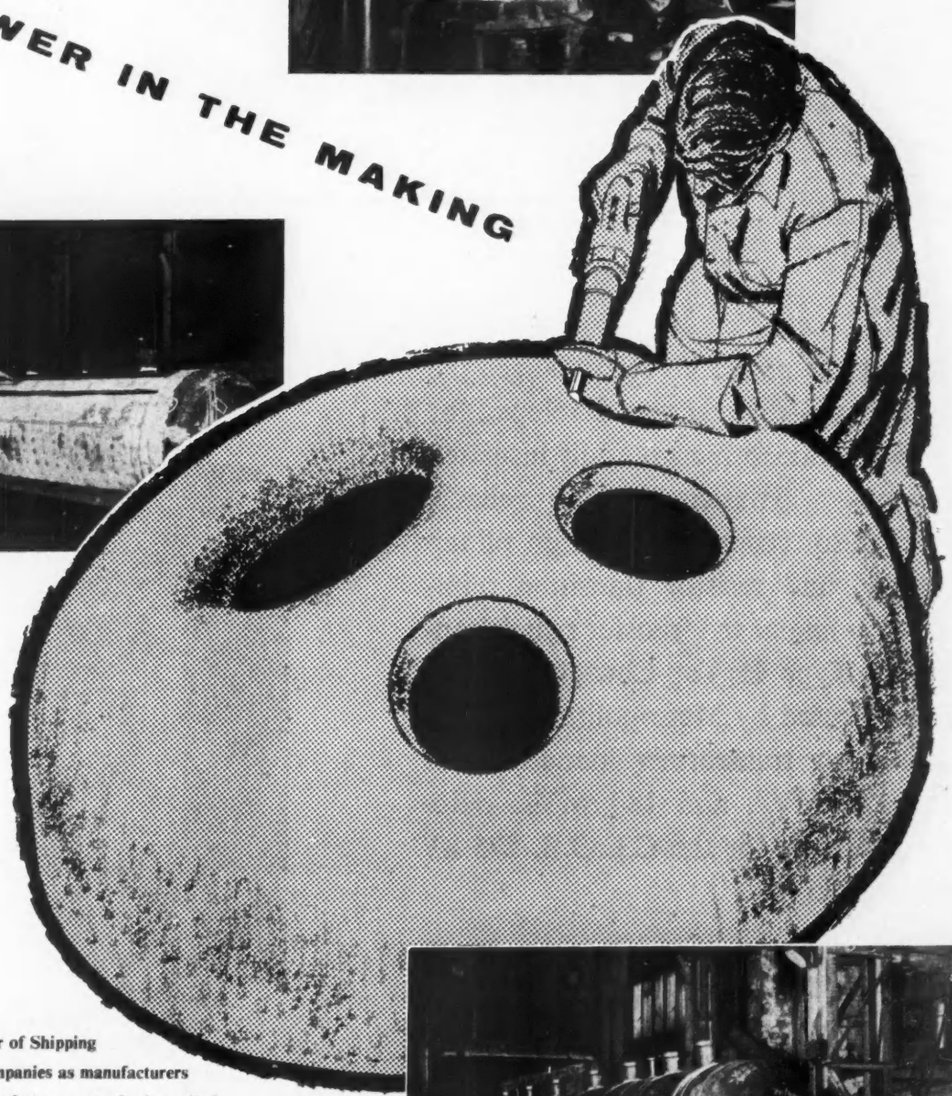
Telephone: TOTtenham 2257-8-9

POWER IN THE MAKING



Accepted by Lloyd's Register of Shipping
and all leading insurance companies as manufacturers
of fusion welded pressure vessels to any standard required.

CLARKE, CHAPMAN & CO. LTD.
Victoria Works · Gateshead, 8 · Co. Durham
LONDON Dunster House, Mark Lane, London E.C.3.
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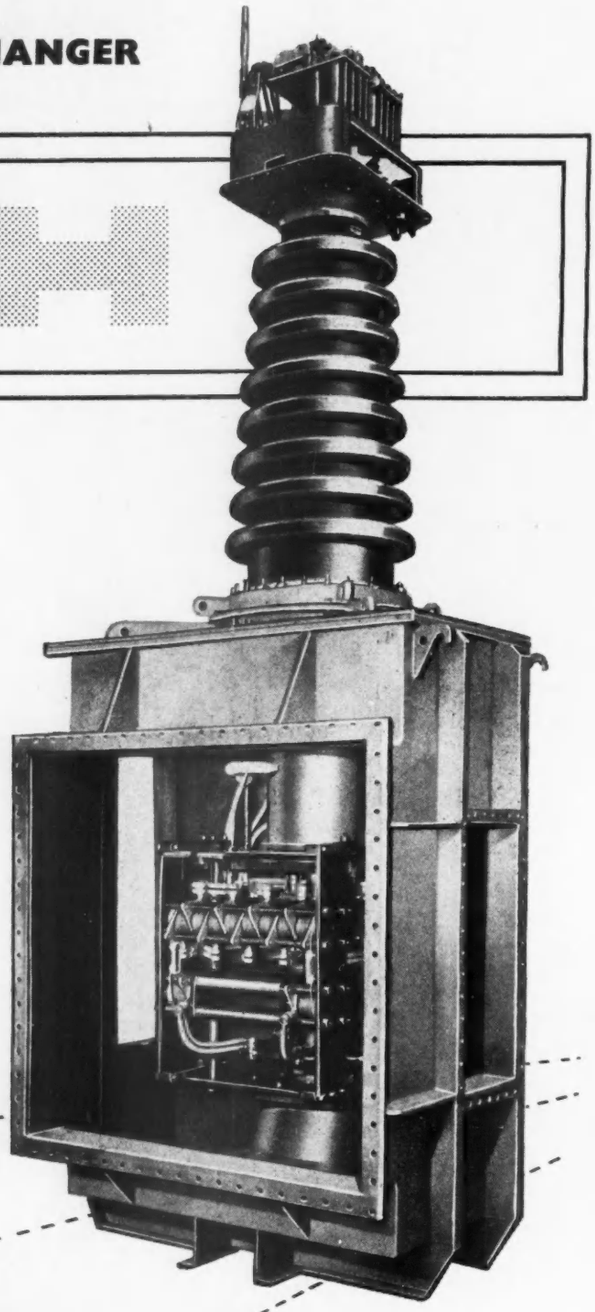
Clarke Chapman

STEAM GENERATING PLANT FOR INDUSTRY

For Service on the Supergrid

TRANSFORMER ON-LOAD TAP-CHANGER

TYPE H



For service at the highest voltages the Type H tap-changer was developed for use with transformers on fully insulated systems. The simple and reliable mechanism ensures completion of tap change, and resistor transition minimises arcing at the transfer switch contacts. Type H Tap-Changing equipment is used by Metropolitan-Vickers and other transformer manufacturers for 120 MVA and 180 MVA auto-transformers for the C.E.G.B. 275 kV supergrid.

METROPOLITAN-VICKERS
ELECTRICAL CO LTD · TRAFFORD PARK · MANCHESTER, 17

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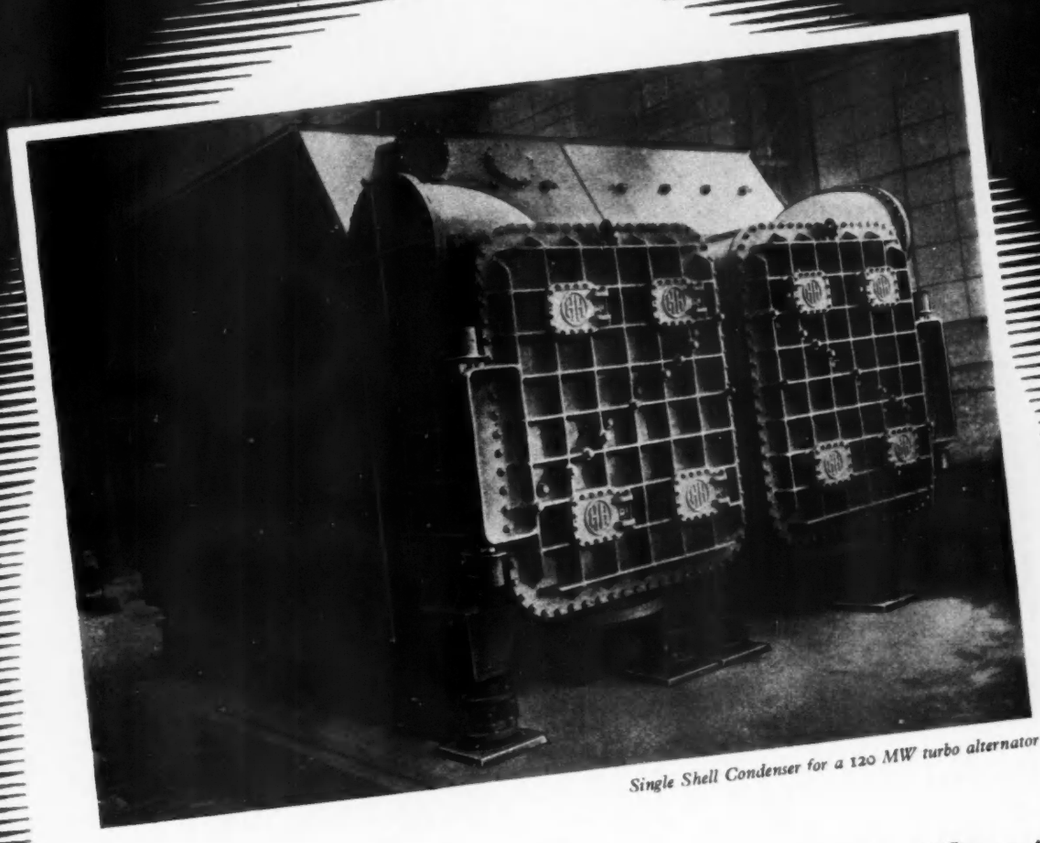
Leading Electrical Progress

E/A504



Single Shell Condenser for a 120 MW turbo alternator

Condensing and Feed heating Plant

Hick Hargreaves, having specialised in the design and production of condensing and feed heating plant for over forty years, now rank as one of the largest independent manufacturers in the country. Improvement in design and production facilities have fully kept pace with the increase in size and complexity of plants, made necessary by the rapid progress which has taken place in the generation of electricity.

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Hick Hargreaves

AND COMPANY LTD · BOLTON

H146

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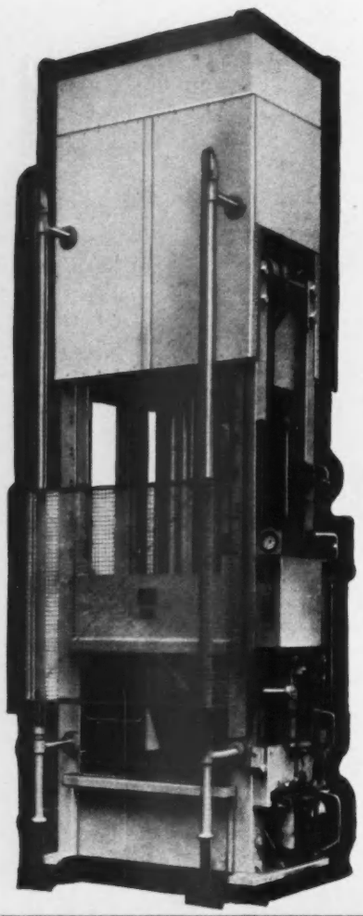

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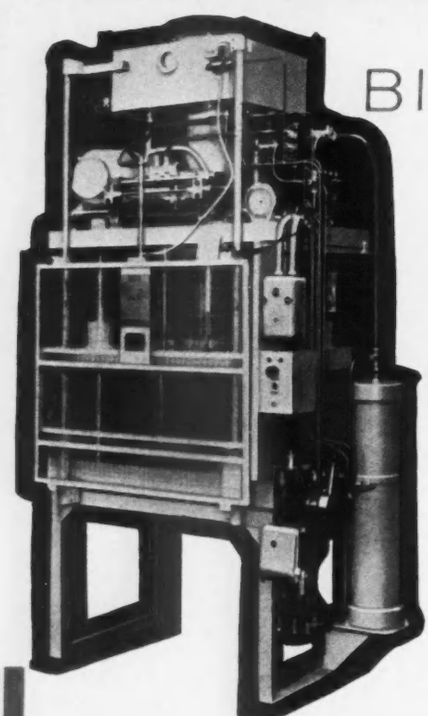
Features of this BIPEL press are its large table area, ample daylight, long stroke ejector gear, and accuracy in operation. Special presses can be made to suit customer's requirements.

HYDRAULICALLY OPERATED MACHINES FOR INDUSTRY



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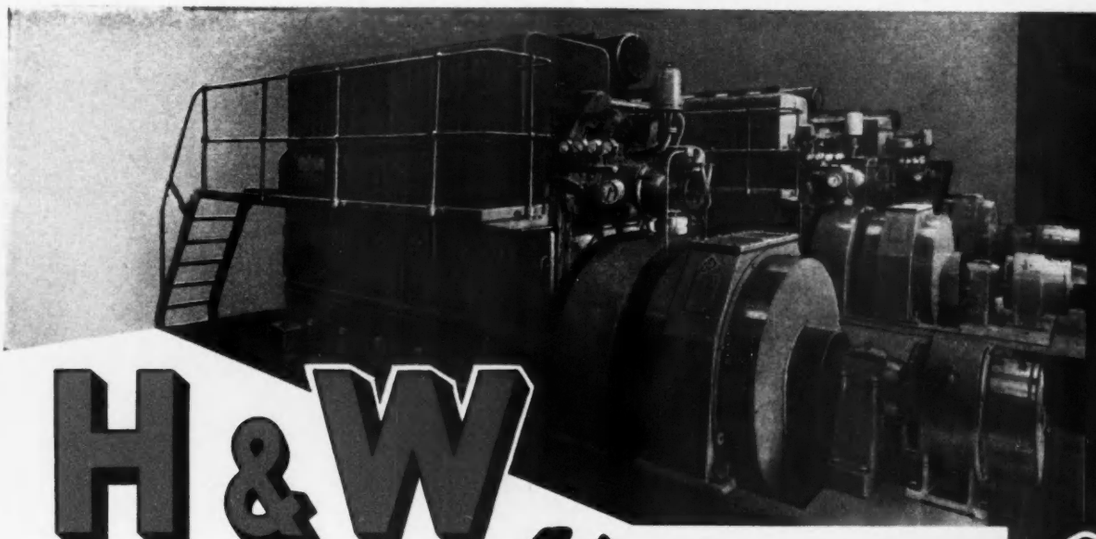
BIPEL—the specialist hydraulic engineers B·I·P

Write for full details to **B.I.P. ENGINEERING LIMITED,** STREETLY WORKS, SUTTON COLDFIELD Telephone: Streetly 2411



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Alternators and engines are of H & W design and manufacture thus ensuring our undivided responsibility for the complete power set. We also supply the necessary control equipment.

H & W alternators supplied in all sizes from 60 to 5,000 kVA and voltages up to 11 kV. with
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FARRAR
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Installed at the New Ford Motor Company Limited foundry at Dagenham - Essex.

These photographs were kindly supplied by The Ford Motor Company Limited, to whom our acknowledgments and thanks are due for permission to publish.

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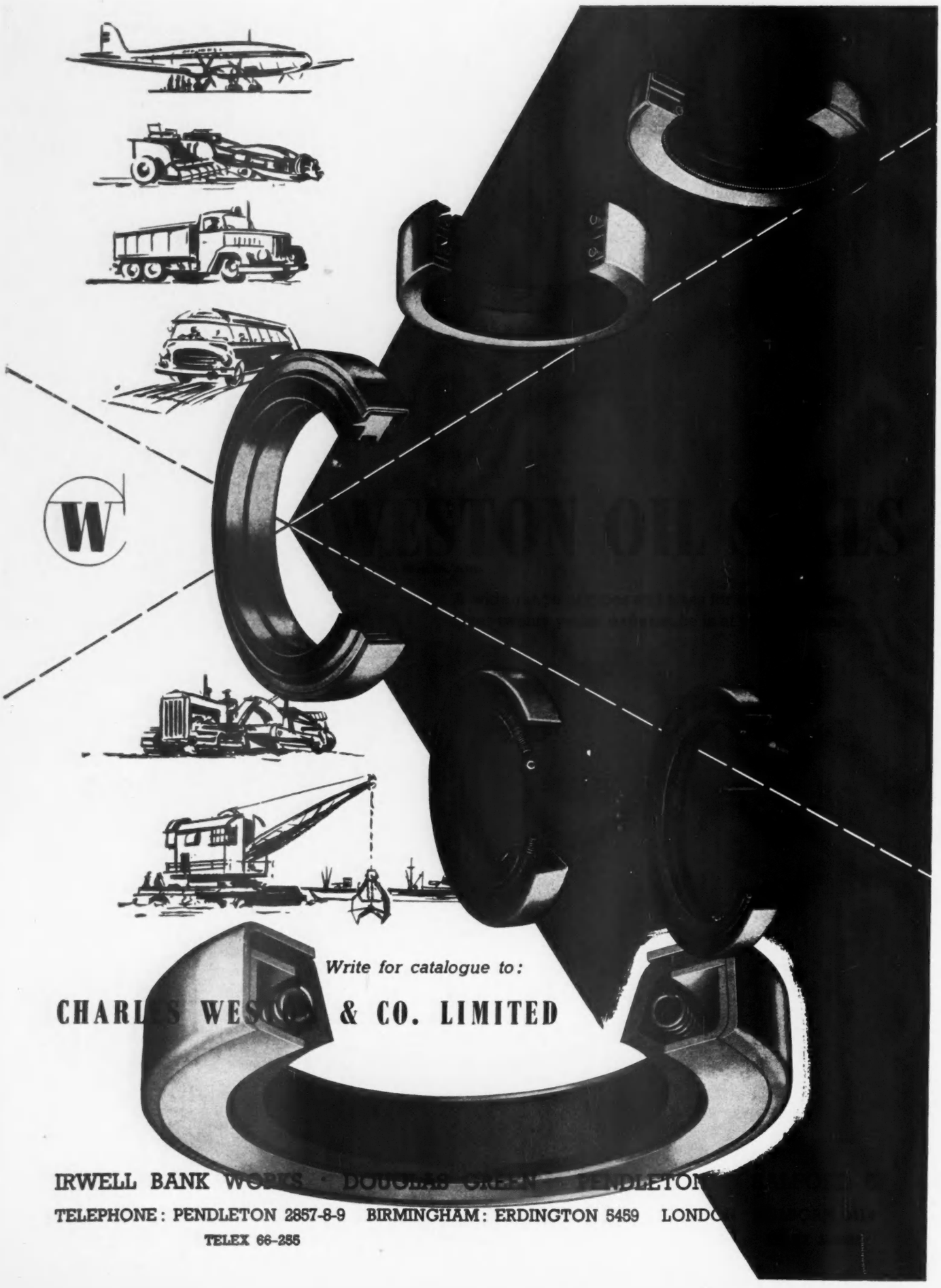
TELEGRAMS FARRAR NEWARK 1143 ★ ★ ★ ★ ★ ★ ★ TELEPHONES NEWARK 1143-4-5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QUANTITY SURVEYORS
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Taylor Woodrow pre-planning, here as elsewhere, includes every modern device and technique to ensure the utmost speed and economy consistent with quality construction to the building owner's high standard. Invariably this means operating to very tight programmes. It is a tribute to the skill, drive and enthusiasm of the Taylor Woodrow men in the field, that the work is so often completed ahead of schedule.

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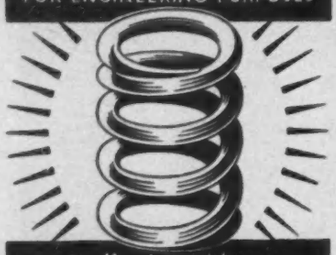
SPRINGS AND SPRING WASHERS
FOR ENGINEERING PURPOSES



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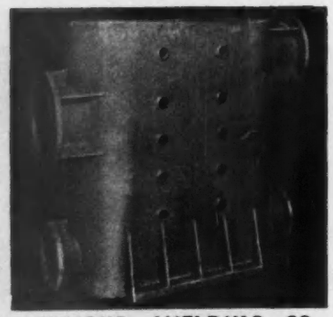
Telephone: SHEFFIELD 24679 Telegrams: TONKS SHEFFIELD 3



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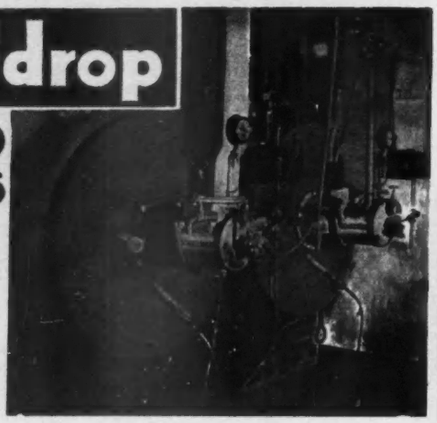

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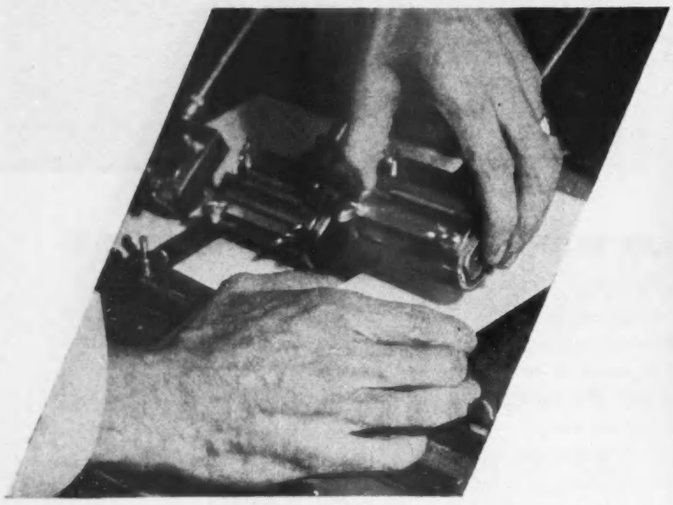

Test and experimental work in P.J. laboratories, carried out in the hands of qualified paint chemists, is the basis of the expert Technical Advisory Service which is offered to all industrial paint users. The services of these skilled hands are directly available through personal contact with your P.J. technical representative.

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for Paint and Service

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Call for an investigation

If a percentage of raw material or end product is lost in dust—if dust is a danger or just a nuisance—then call for an investigation on site by Mancuna. The Mancuna Test Method outlined in these photographs determines the basic collection problems on the spot—under the actual conditions of grain loading, particle size, temperature, humidity and agglomeration, with which the collection plant will have to contend.

Given this exact knowledge and with the high efficiency Mancuna-Dustex collector to back their findings, Mancuna technicians can give you an accurate forecast of results and costs on which to base your decision. If Mancuna equipment is not suitable, we will be the first to tell you and suggest alternative methods.

A leaflet describing the procedure in detail is available on request.

Stage 1
A pitot tube reading is taken to determine gas velocities in the conveying duct.

Stage 2
The single standard miniature cyclone Tube Test assembly. A test is run under operation conditions.

Stage 3
Laboratory analysis shows particle size and other characteristics of samples collected.

Stage 4
Knowing weight of catch sample, and time run on test, Mancuna can determine dust load and percentage of dust recoverable.

Consult
MANCUNA ENGINEERING LIMITED
DENTON, MANCHESTER. Tel.: DENton 3965 (5 lines).

London Office: 59, VICTORIA ROAD, SURBITION, SURREY.
Telephone: Elmbridge 9793.

Specialists in gas cleaning and dust technology.

the largest motor tanker in the world is fitted with TUFNOL rudder bearings

They are justly proud of the "Sven Salén" in Sweden. Built by A. B. Götaverken for the Salen Shipping Companies, this 40,000 ton vessel is the largest motor tanker in the World and possesses many notable features including a 27 ton rudder, larger than any previously fitted in Sweden.
Following modern practice, the rudder is carried in bearings of TUFNOL, the long-life material for rudder and stern tube bearings in ships of all tonnages.

TUFNOL (REGD. TRADE MARK)

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TUFNOL RUDDER AND STERN TUBE BEARINGS AT THE ENGINEERING AND MARINE EXHIBITION

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OUR STAND NO. 3 ROW K GRAND HALL

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TUFNOL LTD. *Perry Barr. Birmingham, 22B*

410

PRESSURE VESSELS AND BOILER DRUMS

CLASS 1 FUSION WELDED BOILER DRUMS and PRESSURE VESSELS can be supplied to BRITISH STANDARD and ASTM-ASME.

Specifications up to the following maximum sizes :— 15 ft. dia. : 4¾ in. thick : 9ft. overall length : 110 tons weight.

PLATES BENT up to 19 ft. 6 in. long and 4¾ in. thick

STRESS RELIEVING on VESSELS up to 45 ft. x 16 ft. x 16 ft. overall.

DISHED ENDS from 18 in. int/dia. up to 7 ft. 6 in. int/dia. and 2 in. thick.

We have supplied ends 74½ in. o/d x 4⅛ thick.

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Engineering & Shipbuilding Works
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OPEN TYPE FLOORING
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STAIRWAYS
PLATFORMS
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Phone : Mayfair 8783-8788

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1959
GERMAN
INDUSTRIES
FAIR
26 APRIL - 5 MAY

For further particulars please apply to
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HANNOVER-MESSEGELÄNDE

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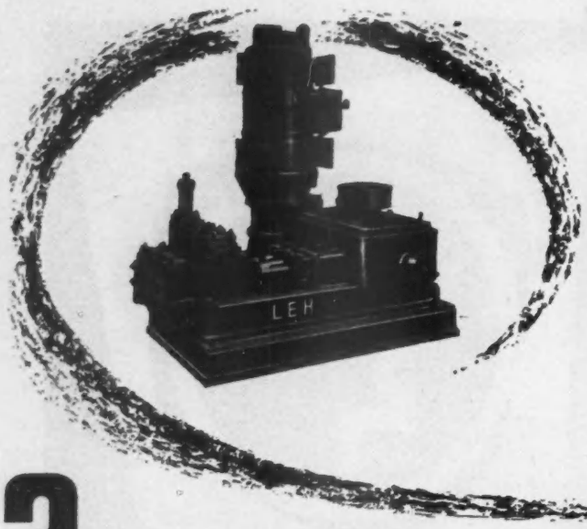

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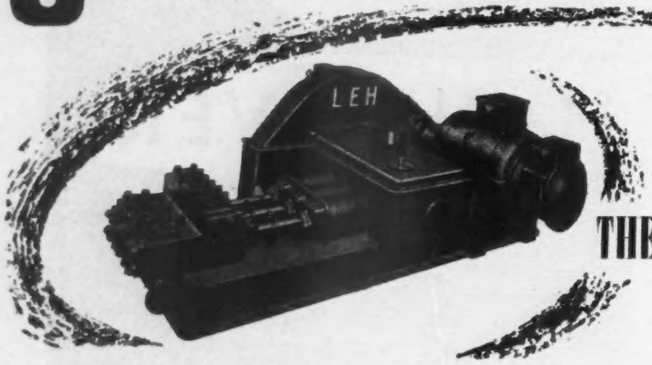
LEH DESIGNERS AND MANUFACTURERS OF HYDRAULIC EQUIPMENT



THE LEEDS ENGINEERING & HYDRAULIC CO., LTD.
RODLEY, LEEDS.
Telephone: 'PUDSEY' 2859.

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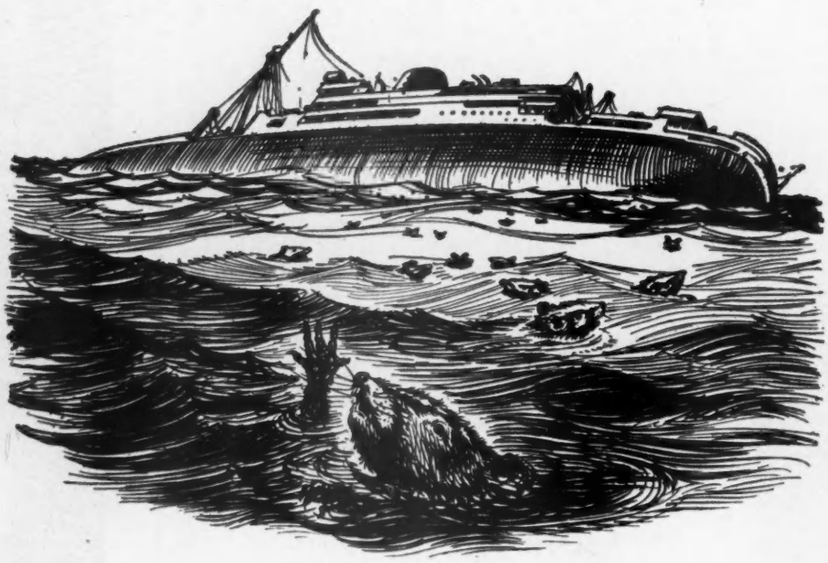

is one way of getting rid of rats, but the best way is to use our pest destruction service. Is your business devoloping a list to the debit side because of the depredations of rats, mice, bugs fleas, ants or cockroaches? Then call us aboard to bring death to these marauders, scientifically, efficiently and regularly. Call us NOW.

BIRMINGHAM: 208 County Chambers, 66½ Corporation Street. Tel.: Central 1176

BRISTOL: Swan House, 112 Hotwell Road, 8. Tel.: Bristol 20512 Ext. 5

EXETER: 21 Church-Lane, Sidwell Street. Tel.: Exeter 54181

EDINBURGH: Pesticidal Services (Scotland) Ltd., 34 Bernard Street, Leith 6. Tel.: Leith 38393

GLASGOW: Pesticidal Services (Scotland) Ltd., 93 Waterloo Street, Tel.: City 0735

SOUTHAMPTON: 14 Howard Road, Shirley. Tel.: Southampton 25307

LEEDS: 21 Upper Mill Hill, Tel.: Leeds 2-5266

LIVERPOOL: 8a Rumford Place, 3, Tel.: Central 2068

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Whether it be a single shape,
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Telephone: Consett 341 (12 lines)
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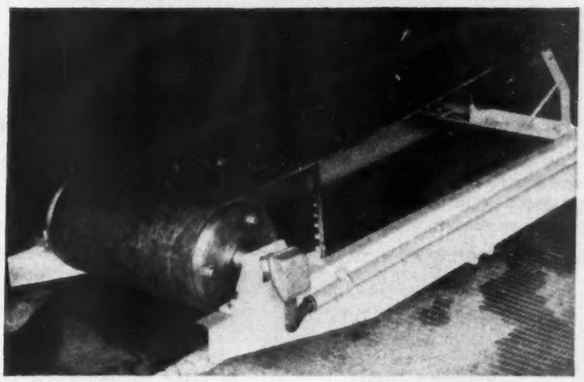
A complete drive Unit in a single, trouble-free head drum!

YOU JUST BOLT IT IN POSITION AND WIRE IT UP!



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A full range of sizes and speeds to suit assembly and picking-belt Conveyors, high-speed bulk Conveyors and certain chain Conveyors. A rugged job at an attractive price. Quick delivery.

The "Thorite" Drum is a joint production of T. & T. Works, Ltd., Billesdon, Leicester, and Richards Structural Steel Company, Ltd., Phoenix Ironworks, Leicester.

THE **THORITE** MOTORISED CONVEYOR DRUM

Write for full details to:
THORITE DRUMS, Phoenix Ironworks, Leicester.

If you want to move X from Y to Z . . . . . get in touch with T. & T.

T&T
CONVEYORS RELEASE MANPOWER

The photograph shows a T. & T. installation in the regional stores depot of a large public department.

T. & T. EXPERIENCE IS WORLD WIDE

T. & T.'s many years' experience on many hundreds of large and small installations at home and abroad is your assurance of satisfaction.

Write for leaflet E., or ask for a technical representative to call and discuss YOUR requirements without obligation.

T. & T. WORKS, LTD., BILLESDON, LEICESTER.

Telephone: Billesdon 261. Telegrams: "Conveyor", Leicester.
London Office: 39, Windsor House, 46, Victoria Street, S.W.1. Telephone: ABBey 6085.

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Lineage Rate. 4/- per line of approximately 6 words. Minimum 16/-.

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Series Discounts. For advertisements 1 inch and upwards. 6 insertions 5%. 13 insertions 10%. 26 insertions 15%.

Run-On and Semi-Displayed Styles. Both these styles are available for single column width advertisements of any depth up to 12 inches.

Displayed and Illustrated Styles. The minimum size for a Displayed advertisement is 3 inches single column, for an illustrated advertisement it is a ¼-page (12 column inches). Thereafter the sizes for both progress in steps 3 inches deep across 1, 2, 3 or 4 columns.

Use of Box Number. 2/- which includes forwarding of replies.

Copy Dates. "Run-on" and "Semi-displayed" advertisements by noon Tuesday for publication on Friday same week. "Displayed" and "Illustrated" advertisements by noon Friday for publication on following Friday. All advertisements three days earlier if proofs are required.

***Advertisements for publication should be addressed to:*—Classified Advertisement Dept., "The Engineer", 28 Essex Street, Strand, London, W.C.2.**

Urgent advertisements may be telephoned to CENtral 6565

PUBLIC APPOINTMENTS

COUNTY BOROUGH OF ROTHERHAM

EDUCATION COMMITTEE

ROTHERHAM COLLEGE OF TECHNOLOGY

HEAD OF THE DEPARTMENT OF MECHANICAL, PRODUCTION AND CIVIL ENGINEERING

Applications are invited for appointment as HEAD OF THE DEPARTMENT OF MECHANICAL, PRODUCTION AND CIVIL ENGINEERING to commence duties on 1st September, 1959.

Candidates should hold a degree and professional qualification and have had industrial and teaching experience. Organising and administrative experience in a Technical College or similar Institution will be an advantage.

Salary in accordance with the Burnham (Further Education) Report, 1956, for Heads of Department, Grade IV, viz., £1750 by £50 to £1900. This scale is subject to the 5 per cent. increase.

Application forms and further particulars may be obtained from the undersigned to whom they should be returned within a fortnight of the appearance of the advertisement.

R. BLOOMER,
Director of Education.

Education Offices,
Rotherham. E5316

UNIVERSITY OF SYDNEY

LECTURESHIPS

Applications are invited for the following Lectureships within the University of Sydney :

(1) LECTURESHIP IN ELECTRICAL ENGINEERING :

Applicants should hold an honours degree in Electrical Engineering, or in Science with Physics as a major subject, and should have had industrial or research experience in the design and applications of vacuum tube circuits. The successful applicant will take part in research and teaching in the field of electronics.

(2) LECTURESHIP IN ELECTRICAL ENGINEERING :

Applicants should hold an honours degree in Electrical Engineering and should have had experience in the design and use of electrical machinery. The successful applicant will take part in research and teaching in the field of electrical machines. Other things being equal, preference will be given to an applicant who has at least a working knowledge of electronic techniques.

Salary for a Lecturer is within the range £A1500 by £A90 to £A2100 per annum, plus cost of living adjustment and will be subject to deductions under the State Superannuation Act. The commencing salary will be fixed according to the qualifications and experience of the successful applicant.

Under the Staff Members' Housing Scheme in cases approved by the University and its Bankers, married men may be assisted by loans to purchase a house.

Further particulars and information as to the method of application may be obtained from the Secretary, Association of the Universities of the British Commonwealth, 36, Gordon Square, London, W.C.1.

The closing date for the receipt of applications, in Australia and London, is 9th May, 1959. E5280

COUNTY BOROUGH OF EAST HAM EDUCATION COMMITTEE

EAST HAM TECHNICAL COLLEGE

LABORATORY ASSISTANT

Applications are invited for the post of LABORATORY ASSISTANT in the Mechanical Engineering Laboratories of the College. Applicants must have completed an Engineering Apprenticeship. Wages £11 14s. 8d. per week of 44 hours.

Form of application (returnable 18th April, 1959) and further particulars may be obtained from the Chief Education Officer, Town Hall Annexe, Barking Road, East Ham, E.6. E5352

PUBLIC APPOINTMENTS

MANCHESTER COLLEGE OF SCIENCE AND TECHNOLOGY

(FACULTY OF TECHNOLOGY IN THE UNIVERSITY OF MANCHESTER)

APPOINTMENT OF LECTURERS OR ASSISTANT LECTURERS IN MECHANICAL ENGINEERING

The Governing Body invites applications for LECTURESHIPS or ASSISTANT LECTURESHIPS IN MECHANICAL ENGINEERING in the Manchester College of Science and Technology, with corresponding title and status in the University of Manchester.

The Department covers a very wide range of aspects of Mechanical and Production Engineering and all members of staff are expected to undertake, assist in, or supervise research in some appropriate field.

Salary : LECTURER : £900 by £50 to £1350 by £75 to £1650. ASSISTANT LECTURER : £700 by £50 to £850.

Commencing salary according to qualificati ons and experience. F.S.S.U. and family allowances.

Conditions of appointment and form of application may be obtained from the Registrar, The Manchester College of Science and Technology, Manchester, 1. The last day for the receipt of applications is Saturday, 18th April, 1959. E5309

QUEEN MARY COLLEGE
UNIVERSITY OF LONDON

LECTURER IN NUCLEAR ENGINEERING

Applications are invited for the post of LECTURER IN NUCLEAR ENGINEERING. The Nuclear Engineering laboratories are being extended and facilities will be available for research in the fields of reactor physics, heat transfer and reactor stability and control. Salary scale £900 by £50 to £1350 (efficiency bar) : £1425 by £75 to £1650, plus London allowance of £60, F.S.S.U. participation and family allowance of £50 for each child.—Application forms, obtainable from the Registrar, Queen Mary College, Mile End Road, London, E.1, to be returned by May 6th. E5335

NORTHAMPTON COLLEGE OF ADVANCED TECHNOLOGY,
ST. JOHN STREET, LONDON, E.C.1

CIVIL AND MECHANICAL ENGINEERING DEPARTMENT

SENIOR LECTURERS AND LECTURERS

Applications are invited for appointments of SENIOR LECTURERS and LECTURERS in subjects of Civil and/or Mechanical Engineering. These appointments are additional to the present staff and arise from the rapid growth in the work of the College in courses for the Engineering Degree and Diploma in Technology, and in post-graduate courses and research.

Salary scales : Senior Lecturer, £1455, rising to £1677. Lecturer : £1297, rising to £1467.

Further particulars and forms of application are obtainable from the Secretary, to whom applications should be sent by 24th April.

J. S. TAIT, Ph.D., B.Sc. (Eng.), M.I.E.E.,
E5315 Principal.

NORTH STAFFORDSHIRE ROYAL INFIRMARY,
STOKE-ON-TRENT

SENIOR ENGINEER

SENIOR ENGINEER required, responsible to Group Superintendent Engineer. Sound knowledge of steam boiler plant and wide experience of mechanical and electrical services desirable, with recognised qualifications.

Salary : £680 rising to £815 p.a. Whitley Council conditions of service.

Applications by 8th April, 1959, giving age, qualifications, experience with names and addresses of two referees (one technical) to Group Secretary, Stoke-on-Trent H.M.C., Princes Road, Stoke-on-Trent. E5314

PUBLIC APPOINTMENTS

CITY OF BRADFORD

ENGINEERING ASSISTANTS

Applications are invited for the following superannuable appointments in the City Engineer and Surveyor's Department, on the grades indicated.

(a) SENIOR ENGINEERING ASSISTANT, Post 18, A.P.T. IV (£1025–£1175).

(b) ENGINEERING ASSISTANTS, Posts 13 and 119, Special Grade (£750–£1030).

(c) ENGINEERING ASSISTANTS, Posts 37 and 120, Grade A.P.T. I or Special (£575–£725 or £750–£1030, according to qualifications).

(d) JUNIOR ENGINEERING ASSISTANTS, Posts 63, 65, 174, Grade A.P.T. I (£575–£725).

Applicants for Post (a) should preferably hold an Engineering Degree, be A.M.I.C.E./A.M.I.Mun.E., and have had special experience in design of reinforced concrete and steel structure for multi-storey flat construction.

Applicants for (b) should preferably hold an Engineering Degree, be A.M.I.C.E./A.M.I.Mun.E., and have had a good general civil engineering training.

Applicants for (c) should have completed their professional training. Salary on Special Grade will be payable to the successful candidates holding an Engineering Degree or is A.M.I.C.E./A.M.I.Mun.E.

Applicants for (d) should have completed their professional training and have had experience in municipal and/or civil engineering.

Applicants should have completed their National Service. No housing accommodation can be provided by the Corporation.

Applications on form to be obtained from the City Engineer and Surveyor, Town Hall, Bradford, 1, together with three testimonials, must be received by the undersigned by 17th April, 1959.

W. H. LEATHEM,
Town Clerk.

Town Hall, Bradford, 1. E5328

TRINIDAD AND TOBAGO ELECTRICITY COMMISSION

VACANCY FOR SHIFT CHARGE ENGINEER

The Trinidad and Tobago Electricity Commission has a vacancy for a SHIFT CHARGE ENGINEER.

Applicants should have experience in the operation of modern steam turbines, water-tube boilers and diesel generators, and must have Graduate Membership of the I.E.E., or I.Mech.E., or Associate Membership of the I.Mar.E., or the Higher National Certificate in Mechanical Engineering, or Second Engineer's M.O.T. Diesel and Steam Certificate or R.N. equivalent.

The annual salary is £1310, rising by annual increments of £40 to £1430.

A partly furnished house will be provided at a rent of £10 8s. 4d. per month, plus a small extra charge for heavy furniture.

An outfit allowance of £60 is paid on arrival in Trinidad.

First-class passages to Trinidad will be provided for the sucessful applicant, his wife and children, up to a maximum of four adult passages. First-class leave passages to the United Kingdom will be provided every three years.

There is a superannuation scheme similar to the C.E.A. and Area Board's scheme.

Information on Trinidad can be obtained from the West India Committee, 40, Norfolk Street, London, W.C.2.

Applications, giving full details of qualifications, age, experience, &c., together with copies of two recent testimonials, should be sent by Air Mail to reach the General Manager, Trinidad and Tobago Electricity Commission, P.O. Box 121, Port of Spain, Trinidad, W.I, by 18th April, 1959. E5338

MINISTRY OF LABOUR AND NATIONAL SERVICE

ENGINEERING AND CHEMICAL INSPECTORS

Pensionable posts for men and women. Age : normally at least 35 and under 40 on 1st March, 1959 ; extension for regular Forces service and Overseas Civil Service. Duties include giving expert advice on questions which arise from administering Factories Acts. Qualifications : Corporate Membership of appropriate Professional Institution, or, for Chemical Inspector posts, Honours Degree (at least Second Class) in appropriate subjects. At least 2 years' relevant industrial or supervisory experience desirable. Men's starting salary (London) from £1325 (35) to £1425 ; maximum £1780. Promotion prospects.—Write, Civil Service Commission, 17, North Audley Street, London, W.1, for application form, quoting S4963/59. Closing date 8th May, 1959. E5330

PUBLIC APPOINTMENTS

ROYAL NAVAL SCIENTIFIC SERVICE

SENIOR SCIENTIFIC OFFICERS AND SCIENTIFIC OFFICERS

Royal Naval Scientific Service requires SENIOR SCIENTIFIC OFFICERS and SCIENTIFIC OFFICERS for Establishments in London area, Baldock, Portsmouth, Portland, Poole and Rosyth. Main requirements are for PHYSICISTS, MECHANICAL ENGINEERS, ELECTRONIC ENGINEERS and MATHEMATICIANS in areas specified. The following particular vacancies also exist : Mathematician : for applied research of basic nature on stability of underwater vehicles ; knowledge of theoretical hydrodynamics and theory of control systems an advantage : London area. Mechanical Engineer : with sound knowledge of basic principles of thermo and fluid dynamics, to carry out research programme in a particular field of applied hydrodynamics. Experience in modern methods of design and research on axial flow compressors, turbines or pumps an advantage : London area. Mechanical Engineers : for design and development of underwater devices ; Portland area. Physical Chemist : with specialised knowledge of rubber technology : Poole area. Chemists : Physical and Inorganic : Poole, Baldock and London areas. Candidates must normally be natural born British subjects of natural born British parents, with First or Second Class Honours Degrees. S.S.O.'s must have had three years' post-graduate experience and be not less than 26 years of age.

Salaries (men) : S.S.O., £1233–£1460 ; S.O., £655–£1150 (London)—somewhat lower in provinces. Appointments are unestablished (with F.S.S.U. benefits), but opportunities may occur for those between ages of 21 and 32 to compete for established posts.

Forms from M.L.N.S., Technical and Scientific Register (K), 26, King Street, London, S.W.1 (quote A.500/8A). E5161

BRITISH TRANSPORT DOCKS

CHIEF DOCKS ENGINEER'S DEPARTMENT

ENGINEERING ASSISTANT

British Transport Docks invite applications for the position of ENGINEERING ASSISTANT in the Chief Docks Engineer's Department, (Humber Ports), Hull.

Applicants must be qualified in reinforced concrete design and have experience in preparing contract drawings and bills of quantities ; experience of dock and harbour structures an advantage. Must have Corporate Membership of the Institution of Civil Engineers or of the Institution of Structural Engineers. Commencing salary £1045 per annum, contributory superannuation scheme and certain rail travel facilities.

Applications, giving age, experience and present position, should be forwarded to : Staff and Establishment Officer, British Transport Docks, 163, Euston Road, London, N.W.1, to arrive not later than Wednesday, 22nd April, 1959. E5312

DEPARTMENT OF SCIENTIFIC AND INDUSTRIAL RESEARCH

NATIONAL PHYSICAL LABORATORY, TEDDINGTON, MIDDLESEX

ASSISTANT EXPERIMENTAL OFFICER

National Physical Laboratory (D.S.I.R.), Teddington, Middlesex, requires ASSISTANT EXPERIMENTAL OFFICER for the Metallurgy Division, preferably with some engineering training. Qualifications : H.N.C. in Mech. Eng. or equivalent. Post unestablished initially, but prospects of establishment through the Civil Service Commission if under 28. Salary range : £397 10s. (age 18) to £880 (men). Five-day week.—Forms from M.L.N.S. Technical and Scientific Register (K), 26, King Street, London, S.W.1, quoting C.60/9A. Closing date 24th April, 1959. E5337

PUBLIC APPOINTMENTS

CEYLON TRANSPORT BOARD

VACANCY—POST OF CHIEF ENGINEER

Applications are invited from persons with professional qualifications comparable to Associate Membership of the Institutions of Civil, Mechanical or Electrical Engineers (England), for the post of CHIEF ENGINEER, Ceylon Transport Board.

The Ceylon Transport Board is a nationalised undertaking operating Road Passenger Transport Service over the entire Island of Ceylon. The operation of the Board's fleet, covering over 300,000 miles per day, is controlled from 58 depots in various parts of the Island.

Applicants should not be less than 35 years of age and be able to organise and maintain a fleet of 3000 motor vehicles and ancillary garages, workshops, &c.

The post carries a salary of £2000 per annum, tax free. A motor-car and free furnished apartments will also be provided. For an exceptionally well-qualified person, a higher salary will be considered. The appointment will be on contract for 3 years with option for renewal thereafter if both parties agree.

Applications, stating salary required, age and full particulars of qualifications and experience and accompanied by copies of recent testimonials, should reach the undersigned not later than 18th April, 1959.

Candidates will be required to present themselves for an interview at their own expense at the office of the Ceylon High Commissioner for the United Kingdom, at the address given below.

(Sgd.) V. M. ABEYSEKERA,
For High Commissioner for Ceylon
in the United Kingdom.

13, Hyde Park Gardens,
London, W.2.
3rd April, 1959. E5320

EAST WORCESTERSHIRE WATERWORKS COMPANY

ENGINEER-MANAGER

Applications are invited for the appointment of ENGINEER-MANAGER. Candidates must be fully and suitably qualified and with the necessary experience of waterworks practice and administration, between the ages of about 45–50 years.

The salary will be £2500 per annum, rising to £3000 per annum.

The successful candidate will be required to pass a medical examination and to join the Company's superannuation scheme under the Worcestershire County Council.

Applications, giving the names of three persons to whom reference may be made, should be addressed to A. M. Hardy, F.C.I.S., Secretary, 2, Stourbridge Road, Bromsgrove, Worcestershire, to be received by 20th April, 1959, and endorsed "Engineer-Manager." E5347

PUBLIC APPOINTMENTS

COUNTY BOROUGH OF ROCHDALE

RESIDENT ENGINEER

Applications are invited for the appointment of a RESIDENT ENGINEER/CLERK OF WORKS, to supervise the construction, internal and external finishes of the first stage of the new Rochdale College and also the construction of the diversion and improvement of a length of the River Roch.

The salary will be between £1300 and £1500 per annum, according to age and experience. The appointment will be temporary and subject to satisfactory service, and is expected to last for approximately 2 years, but may be terminated by one month's notice on either side. Applicants, who must have had experience of similar work, should apply in writing to the undersigned, not later than 12 noon, on the 9th April, 1959, giving full particulars of age, qualifications and experience, together with the names of two referees.

K. H. MOORE,
Town Clerk.

Town Hall,
Rochdale,
Lancs. E5341

PHYSICISTS and an ENGINEER

are required to devise and demonstrate experiments and subsequently to lecture on reactor physics and reactor engineering at the Reactor School, Atomic Energy Research Establishment, Harwell. Applicants should be honours graduates, members of the Institute of Physics or professional engineers, with experience in teaching and, preferably, in laboratory management; specialised training in the atomic energy field will be given. Salary £1345–£1800.

Please send a Postcard to the Group Recruitment Officer (1360/25), U.K.A.E.A., A.E.R.E., Harwell, Berks, for details.

E5324

PUBLIC APPOINTMENTS

MECHANICAL ENGINEER

is required at Aldermaston to take control of a section which provides a service covering Inspection, Metrology and Metallurgy at all stages of production to assembly and testing.

The work is mainly of a fundamental nature, involving very high accuracy metrology techniques applied to scientific equipment, radioactive and other non-conventional materials.

Applicants must be Corporate Members of one of the Senior Engineering Institutions and have had wide experience in the Engineering Industry, particularly in the high-precision field.

A good working knowledge of Metallurgy is desirable and a knowledge of modern metrology methods is essential.

This is a Senior appointment and the Salary is in the range £2200–£2600.

Contributory Superannuation Scheme. A modern house with garage or, alternatively, substantial assistance with house purchase will become available for married officers living beyond daily travelling distance.

POSTCARDS for application forms to the Senior Recruitment Officer at Atomic Weapons Research Establishment, Aldermaston, Berks. Please quote ref. 2205/25.

E5310

TENDERS

FEDERATION OF RHODESIA AND NYASALAND

FEDERAL POWER BOARD

KARIBA HYDRO ELECTRIC SCHEME

The Federal Power Board will shortly be calling for TENDERS for the SUPPLY, DELIVERY, ERECTION and MAINTENANCE of AIR CONDITIONING EQUIPMENT for Kariba Power Station, situated on the Zambesi River in the Federation of Rhodesia and Nyasaland, at an altitude of 1250ft. above sea level. The average daily maximum ambient air temperature during the summer period is 38 deg. Cent., and the approximate volume to be conditioned is $2{\cdot}4 \times 10^6$ cu. ft.

The Air Conditioning Equipment will be required to maintain an average temperature of 32 deg. C. at roof level, the approximate heat gain from the equipment accommodated in the Power Station being 950kW.

Contractors who may be interested in Tendering for this equipment should submit full details of their qualifications and experience by 24th April, 1959, after which Tender documents and drawings will be issued to those contracting organisations who satisfy the requirements of the Board.

Details, qualifications and experience should be sent in duplicate to the Secretary, Federal Power Board, P.O. Box 630, Salisbury, Southern Rhodesia, with a copy to the Electrical and Mechanical Consulting Engineers, Merz and McLellan, Carliol House, Newcastle upon Tyne, 1. E5325

RAND WATER BOARD

JOHANNESBURG, SOUTH AFRICA

CONTRACT NO. 919

SUPPLY AND DELIVERY OF 84-INCH INTERNAL DIAMETER PIPE, EXCAVATION OF PIPE TRENCHES, &c., AND LAYING AND JOINTING OF PIPE FOR A PIPELINE APPROXIMATELY 62,500 FEET IN LENGTH

Tenders are hereby invited for the supply and delivery of the above-mentioned pipe, excavation of pipe trenches, &c., and laying and jointing of a pipeline under Contract No. 919.

Copies of the contract documents may be obtained from the Chief Engineer (Mr. C. P. Robinson, B.Sc., M.I.C.E., M.(S.A.)I.C.E.), 3, Fraser Street, P.O. Box 1127, Johannesburg, or from Ranald J. Harvey and Partners, 34, Victoria Street, Westminster, London, S.W.1, England, on payment of a deposit of £5 in respect of the first copy and £2 for each additional copy.

Deposits for documents will be refunded on receipt of a bona fide tender or, in the event of failure to submit a tender, on return of the documents within one month of the date tenders are opened.

Tenders endorsed "CONTRACT No. 919—TENDER FOR 84-INCH PIPELINE" must be sealed and delivered to the undersigned before NOON on WEDNESDAY, 29th JULY, 1959.

The Board does not bind itself to accept the lowest or any tender.

N. McMURRAY,
Secretary.

3, Fraser Street,
P.O. Box 1127,
Johannesburg.
South Africa.
6th March, 1959.
Notice No. 1077 E5183

MANCHESTER REGIONAL HOSPITAL BOARD

BUILDING AND ENGINEERING CONTRACTS

The Board are prepared to receive from Main Building Contractors and Main Engineering Contractors not already on the Board's Approved List of Contractors, applications for inclusion in such List.

Interested contractors should write to the Secretary of the Board, Cheetwood Road, Manchester, 8, for form of application and further details not later than the 18th April, 1959. E5353

TENDERS

INDIA STORE DEPARTMENT

WELDABLE SEAMLESS STEEL TUBES

The Director General of India Store Department, Government Building, Bromyard Avenue, Acton, London, W.3, invites TENDERS for the SUPPLY of :—

	Quantity, Feet
WELDABLE SEAMLESS STEEL TUBES :—	
(a) 1¼in./1¼in. dia.	7,500
(b) 5¼in./4½in. dia.	950
(c) 1¼in./⅝in. square	46,500

To DIN. 1629.

Forms of Tender may be obtained from the above address on or after the 3rd April, 1959, at a fee of 10s., which is not returnable. If payment is made by cheque, it should please be made payable to "High Commissioner for India." Tenders are to be delivered by 2 p.m. on Thursday, 14th May, 1959.

Please quote reference No. 44/58/RLY. E5323

EDUCATIONAL

CIVIL SERVICE COMMISSION

GOVERNMENT SCIENTIFIC ESTABLISHMENTS

RESEARCH FELLOWSHIPS

RESEARCH FELLOWSHIPS (3 years) in Government Scientific Establishments. Value £1100–£1350 (Senior) and £750–£1000 (Junior). Very wide range of topics, especially in the physical sciences. A few opportunities for Biologists, e.g. in Virology, Taxonomy and Physiology as applied to Fisheries and Veterinary Research.

Qualifications: normally First or Second Class Honours Degree; evidence of high standard of ability in research; and at least 2 years' post-graduate research experience (3 years for Senior Fellowships). No age limits. F.S.S.U.

Write, Civil Service Commission, 17, North Audley Street, London, W.1, for application form, quoting S4932/59. E5313 g

UNIVERSITY OF SHEFFIELD

NON-DESTRUCTIVE TESTING OF MATERIALS

A Course of Experts' Lectures and Demonstrations of the latest techniques will run from 4th to 15th May next.

HYDRAULIC OPERATION AND CONTROL OF MACHINES

Lectures on Principles and Applications, Demonstrations and Works Visits are included in a Course to run from 25th May to 5th June next.

For details of these Courses apply to Professor of Applied Mechanics, University of Sheffield, Mappin Street, Sheffield, 1. E5327 g

TECHNICAL HOME STUDY COURSES

For A.M.I.Mech.E., A.M.I.Chem.E., A.M.I.M.I., A.F.R.Ae.S., C. & G., &c.

OVER 50 FIRST PLACES and more than 2000 Passes have been secured by T.I.G.B. Students at Professional Engineering Examinations. We have a wide range of exclusive Home Study Courses in all branches of Engineering—Mechanical, Electrical, Aeronautical, Automobile, Chemical, Gas, Radio, and Television, Draughtsmanship, &c. Textbooks, blueprints, &c., are provided and, if desired, fees may be paid by moderate instalments.—Write (stating subject of interest) for copy of 110-page Prospectus FREE and without obligation.

THE TECHNOLOGICAL INSTITUTE OF GREAT BRITAIN
(Dept. 76),
29, WRIGHTS LANE, LONDON, W.8.
E102 g

Physicists and Engineers

for Dounreay

The expansion of the nuclear power programme requires a steady supply of reactor technologists. The Reactor Division of the Dounreay Experimental Reactor Establishment at Thurso, Scotland, has vacancies for physicists and engineers which afford an excellent opportunity for a thorough training in the necessary techniques. These posts are concerned with the operation of the Fast and Materials Testing Reactors and will provide experience in dealing with operational and organisational problems. As the plant will operate wholly or partly on a continuous basis, some of the posts entail shift working.

Applicants must either have served a recognised engineering apprenticeship and be corporate members of a senior engineering institution, or possess an honours degree, or equivalent, in physics. Wide experience in research or industry is required for the more senior posts.

Salary between £1855 and £2155, £1345 and £1800 or £845 (at age 25) and £1315, according to qualifications and experience.

Contributory Superannuation. Staff Housing Scheme. Hostel accommodation may be available.

Write for application form, quoting reference 3019/J.1 *to:*

Personnel Manager, U.K.A.E.A. (I.G.)

DOUNREAY EXPERIMENTAL REACTOR ESTABLISHMENT,

Thurso, Caithness, Scotland. *Closing Date: 20th April*, 1959.

E5331

Classified Advts. continued on page 92

EDUCATIONAL

A.M.I.MECH.E., B.Sc., City and Guilds, &c. Guarantee Postal Courses for all Exams. and Technical Divisions from Elementary to Degree standard including Automation Techniques. Approximately 95 per cent. successes. 148-page prospectus free on request.—B.I.E.T. (Dept. 22), 29, Wright's Lane, London, W.8. E114 E

AUTOMATION.—AUTHORITATIVE COURSES are now available in Digital and Analogue Computer Technology, Applied Electronics, Data Processing and Instrumentation up to professional level by home study. Individual enrolment or industrial group scheme enrolments accepted. Syllabuses and prospectus sent on request.—Write (Dept. S.E.8), E.M.I. Institute School of Electronics, College House, Kensington, London, W.8. E145 E

SITUATIONS VACANT

APPLICANTS ARE ADVISED TO SEND COPIES, NOT ORIGINALS, OF THEIR TESTIMONIALS UNLESS OTHERWISE REQUESTED.

A PLANT MANAGER required to take full charge of opening a new medium-size precision ball plant. Very attractive salary and bonus.—Application, which will be treated in the strictest confidence, with full details of experience and qualifications, to BOX No. E5321, "The Engineer." A

A.E.I.-HOTPOINT LTD.
have vacancies for :—

SENIOR & JUNIOR

REFRIGERATOR DESIGN ENGINEERS

in their Design Division at Peterborough.

Applicants for senior positions should be qualified to Associate Membership of I.Mech.E. or I.E.E. and those for junior positions must possess H.N.C. with endorsements or a Degree.

Previous experience in the design of domestic or commercial refrigerators, or in products involving similar design problems, is required in one or more of the following fields :—

Sheet metal and cabinet design.
Compressor design.
Refrigerator system processing.
Plastics as applied to refrigerators.
Refrigerator system design.
Heat transfer.
Hot room test procedure.
Preparation of test and process specifications.
Thermal insulation.
Thermostat design.

General working conditions are good, and a Pension Scheme is in operation. Assistance with housing will be given in appropriate cases.

The Company is interested in employing outstanding men and is prepared to pay appropriate salaries.

Applications, giving full particulars of personal history and experience, should be addressed to the :—

Employment Officer,
A.E.I.-Hotpoint Ltd.,
33, Grosvenor Place,
London, S.W.1. E5340 A

APPLICATIONS ARE INVITED FROM ENGINEERS for responsible posts on research and development of PRODUCTION PROCESSES for the engineering industry. Excellent opportunities for those with ability and initiative. Candidates should have an engineering degree, Higher National Certificate, or equivalent qualification. Excellent working conditions in pleasant surroundings. Superannuation scheme. Removal expenses paid.—Send full details, including age, qualifications, experience and present salary, in confidence to BOX No. E5294, "The Engineer." A

ASSISTANT ELECTRICAL ENGINEER required for large aluminium works near Newport, Mon. Applicants should be aged between 30 and 35 and must possess Degree or Higher National Certificate. They should have had practical experience in design, installation, operation and maintenance, of a large power works system, which includes H.T., L.T. and D.C. distribution. Repair shop practice, knowledge of mill electronics and instrumentation an advantage. Canteen facilities are available, pension scheme and sports club, &c.—Write, giving details of experience and qualifications, to Personnel Officer, NORTHERN ALUMINIUM CO., LTD., Bush House, Aldwych, London, W.C.2. E5332 A

COCHRAN AND CO., ANNAN, LTD. require SENIOR TECHNICAL REPRESENTATIVE for the Marketing of Pressure Vessels. Progressive salary and car provided.—Reply, stating qualifications and experience to BOX No. E5279, "The Engineer." A

CRANE OPERATORS for Lorry-Mounted Cranes operating throughout the country. Only responsible men who are able to work on their own initiative and to supervise crews on a variety of erection and installation jobs need apply. Very interesting work. Good prospects. Attractive rates of pay, expenses and bonus. In certain cases training would be given. —Apply in writing, giving full details of past experience, &c., to TARSLAG, LTD., Upper Wortley Road, Rotherham. E5345 A

DESIGN DRAUGHTSMAN required for mechanical design of nucleonic instruments. Pleasant working conditions. Excellent rates of pay.—Apply Chief Draughtsman, ISOTOPE DEVELOPMENTS, LTD., Beenham Grange, Aldermaston, Berks. Tel.: Woolhampton 451. E152 A

DESIGNER/DRAUGHTSMEN with good electrical engineering background required by Consulting Engineers handling a variety of design projects. Positions available are for all grades up to degree standard. Pension scheme and three weeks' annual holiday after qualifying periods.—NORRIS BROTHERS, LTD., 62, Church Road, Burgess Hill, Sussex. E5300 A

SITUATIONS VACANT

CHIEF ENGINEER

A Chief Engineer is shortly to be appointed by a large Organisation of international standing. The position carries with it an Executive Directorship of the company concerned, and the person appointed will be expected to play a full part in the overall direction of the business. In order to ensure that the position is filled by the best possible engineer, the Company is prepared to consider a suitably qualified engineer from outside its own senior staff, and from any industrial or academic sphere.

The post calls for technical leadership of the first order, and the ability to guide and inspire teams working on a variety of electrical and mechanical projects. High engineering qualifications are therefore necessary, together with experience in controlling other technologists at executive level. The Chief Engineer will also have personal contacts with senior executives of customer companies and organisations, and must be prepared for a limited amount of travel. He will be expected to live in Birmingham or the surrounding district.

Commensurate with its seniority, the post will carry a minimum salary of £4000 p.a.

Applications should be made in writing and will be treated in the strictest confidence.—BOX No. E5348, "The Engineer." A

DESIGNER with imagination, having mechanical and structural experience, required in the design and development department of STOTHERT AND PITT LTD., BATH, for work on interesting new projects. Experience in crane work is an advantage. University Degree or associated membership standard essential. E5344 A

DEVELOPMENT ENGINEER.—Wild-Barfield Electric Furnaces, Ltd., have a vacancy for a keen and progressive engineer with good mechanical and electrical experience, to take charge of their development department relating to electric furnace and induction heating equipment. A knowledge of industrial requirements and administrative experience is desirable. Salary in accordance with qualifications and experience ; pension scheme in operation. Applications, giving full details, including experience and salary required, should be addressed to the Technical Director—address—Elecfurn Works, Watford By-Pass, Watford, Herts. E2347 A

DRAUGHTSMAN, Senior, Structural Steelwork experience.—LINDSAY'S PADDINGTON, 41, North Wharf Road, W.2 (Pad. 8485). E5336 A

ELECTRICAL/MECHANICAL ENGINEER required by estates dept. of assurance company to supervise maintenance of lift and boiler installations and ventilating plant and prepare specifications for new installations. Age group 30 to 40. Apply in writing with full details of experience and salary required.—BOX No. E2345, "The Engineer." A

ESTIMATOR required for interesting work in connection with steel structures, hoisting machinery (steam, diesel and electric) and contractors' plant. Previous experience in estimating for general engineering essential. Preference given to applicant with some previous drawing-office and works training. Candidates should have O.N.C. qualification. Age 25–30. Contributory pension scheme, canteen facilities and convenient transport.—Apply in writing, giving full particulars of age, experience, qualification and salary required, to The Personnel Officer, THE BRITISH STEEL PILING CO., LTD., Claydon, Suffolk. E5334 A

IND COOPE LIMITED
invite applications from

ENGINEERS

to fill two new vacancies on their staff. In considering applicants, preference will be given to those with most of the following :
Public School and University Education.
Honours Degree.
Completed Graduate Apprenticeship.
Completed or nearly completed requirements for Corporate Membership of a major Engineering Institution.
Some industrial experience in a responsible position.
Age 25–30.
Excellent personal qualities.

Appointments will be initially at the Company's headquarters and Brewery at Burton-on-Trent and the work will cover a wide field of Plant Engineering. Special assignments at other Breweries and Establishments may also be required from time to time. Replacement value of Plant installed is about £5,000,000.

Salaries will be dependent on experience, qualifications, &c.

Special attention will be given to training for leadership and increasing responsibility.

The Company operates an excellent Pension Scheme with provision for dependents at all stages.

Please write, with details, to the Chief Engineer, Ind Coope Ltd., Station Street, Burton-on-Trent.

E5283 A

JIG AND TOOL DRAUGHTSMAN.—Senior man required as Section Leader in design of tools and equipment for mass production of light electrical components. Practical tool room experience essential. Progressive position in an expanding organisation situated in S.E. London. Apply to Personnel Manager.—BOX No. E2339, "The Engineer." A

PRODUCTION CONTROLLER required for modern and progressive Company engaged in the manufacture of nuclear fuel handling and other precision equipment. The Company is engaged on small batch production and offers good working conditions in new works and offices, with the usual canteen facilities, Staff Pension and Sickness Insurance Scheme.—Please reply in the first instance to The Personnel Manager, JOHN THOMPSON, LTD., Ettingshall, Wolverhampton. E5346 A

SITUATIONS VACANT

LEADING LOADING SHOVEL MANUFACTURER HAS VACANCY for a DESIGN DRAUGHTSMAN for the design and progressing of new developments in hydraulic loading shovels.

Applicants should have experience in medium general engineering fabrication and transmission design and should be able to work with a minimum of supervision.

H.N.C. minimum qualification.

Apply in writing to Chief Designer, F. E. WEATHERILL, LTD., Tewin Road, Welwyn Garden City, Herts. E2336 A

MACHINE SHOP FOREMAN

A large engineering works in the North of England requires an ADDITIONAL SENIOR FOREMAN.

Applicants must have a good record of supervisory experience in medium/heavy general engineering on a range of machines, including horizontal borers, planes, plano-mills and centre lathes. Technical education to H.N.C. level is desirable. Preferred age 28–45.

The company operates a contributory pension scheme and assistance with housing is available. This is a senior staff position of considerable scope and responsibility and will be remunerated accordingly.

Write, initially, with full details of career, to Personnel Manager, BOX No. E5262, "The Engineer." A

ROBERT M. DOUGLAS (CONTRACTORS) LTD.,
require
QUANTITY SURVEYORS in the Midlands and South Wales for building and civil engineering works, including motorways and bridges. Must be contractor trained. Good prospects, pension scheme.—Apply in writing, stating age, qualifications and experience, to 395, George Road, Birmingham. E5153 A

SENIOR CONSTRUCTION ENGINEER

Experienced Site Engineer required to supervise construction of mechanical, electrical and instrument works or major water clarification plant in Middle East. Applicants should be aged 30 to 45 with considerable construction experience overseas for preference. Corporate Membership of one of the professional institutes would be an advantage. The contract will extend for an approximate period of 18 months with good salary and generous allowances. Full details in chronological order.—BOX No. E2343, "The Engineer." A

SENIOR DRAUGHTSMAN REQUIRED.—Established firm mechanical handling engineers. Experience of mechanical handling essential. Good rates of pay and bonus scheme.—BOX No. E2340, "The Engineer." A

STOTHERT AND PITT LTD., Bath, invite applications from DESIGNERS for appointment to their Research Design and Development Department. Applicants should have a sound knowledge of hydraulics with particular reference to positive displacement and centrifugal pumps. Some electrical knowledge would be an advantage. E5343 A

UNITED GLASS, LTD.
ST. HELENS
require a

DESIGN ENGINEER

to specialise in the design and development of equipment used for the manufacture and handling of glass containers.

Applications are invited from young men who have :—
H.N.C. Mech. Eng. or higher qualifications.
Several years' experience in general engineering. Imagination and a progressive outlook.

The successful applicant will be paid a salary commensurate with his qualifications and experience, and will be eligible for membership of the company's staff pension and life assurance scheme.

Please send full particulars of age, qualifications and experience to the Personnel Officer, United Glass, Ltd., Ravenhead Works, St. Helens.

E5329 A

WORKS MANAGER

Works Manager required for modern works employing approximately 200, manufacturing medium and heavy machine tools and hydraulic plant. Candidates, preferably 35–40 years of age, and holding Higher National Certificate, must have first-class experience in workshop practice, production and labour control. Staff Pension Scheme in operation.

Applications, which will be dealt with in confidence, should give full details of qualifications, experience, positions held, and addressed to Hugh Smith and Co. (Possil), Ltd., 97, Hamiltonhill Road, Glasgow, N.2. E5339 A

SENIOR MANAGER.—A steelworks in the West Midlands with an expanding trade in section semis and rounds wishes to engage a Senior Manager to supervise their finishing and despatch departments. Preference will be given to men with experience of roller straightening and ancillary processes. The post is progressive and there is a pension scheme and free life assurance scheme in operation.—Applications, with full details of age, qualifications and experience, to BOX No. E5333, "The Engineer." A

SITUATIONS VACANT

DEVELOPMENT ENGINEER

A progressive South Yorkshire Company with nationally recognised reputation for high quality products require the services of an ENGINEER of outstanding ability with a wide experience of Carbide Tool Design and Application.

Responsibility will include Drawing-Office control, Development Design projects, Methods and Planning, Investigation and Demonstration at Customer's works, and the commercial application of all aspects of Tool Manufacture.

A wide engineering background, based on extensive machine-shop experience, coupled with a sound knowledge of Sales Technique, is essential.

Salary offered will reflect the high level of responsibility involved.

Applications, giving full details of qualifications, experience and present salary (in confidence), to The Personnel Manager, BOX No. E5322, "The Engineer." A

ENGINEERING SALES REPRESENTATIVE

required for company in West Riding area, preferably resident within the area. Qualifications : A.M.I.Mech.E. or University Degree in Mechanical Engineering.

Applications, giving brief details of education, technical qualifications and experience, names of referees and salary required should be addressed to BOX No. E5350, "The Engineer." A

MSL have been retained to advise on the appointment of an

ADMINISTRATIVE MANAGER

for an engineering company manufacturing machinery and equipment for sale to industrial users in the United Kingdom. The company, which is a member of a group of engineering companies of international repute, has been established nearly forty years and follows an active policy of extending its range of products.

The successful applicant will be responsible to the Managing Director for all those duties which may be placed under the heading of General Administration, including Costing and Estimating, Budgetary Control of Materials and Supplies, a large measure of supervisory control of production, responsibility for all staff matters and all that is involved in the day to day administration of an engineering concern.

Candidates must be EITHER qualified Chartered Accountants or Cost Accountants or Company Secretaries with a minimum of ten years' commercial and administrative experience in the engineering industry, OR qualified Mechanical or Chemical Engineers with considerable practical experience (preferably of designing and manufacturing machinery and equipment for the Chemical, Rubber, Paint, Ceramic and Plastic industries) and with some commercial and administrative experience. AND must be individuals whose qualities of leadership are such as will justify promotion to a more responsible position in the company within five years.

Preferred age 37 to 45. Initial salary will be in the region of £2,000 p.a. with use of car.

No information will be disclosed to our clients until candidates know their identity and have given permission after personal discussion. Please send brief details in confidence, quoting reference G.1610, to J. G. Smith.

MANAGEMENT SELECTION LIMITED
17, Stratton Street, London, W.1.
E134 A

SITUATIONS VACANT

THE CUBITT GROUP

require

MECHANICAL ENGINEERS

who must be experienced in the erection of vessels and pipework and heavy machinery, and familiar with Class I welding techniques.

PLANT MAINTENANCE ENGINEERS

experienced in field and workshop maintenance and overhaul of large Excavators, Tractors, Heavy Transport and Cranes.

Applicants are required to work in U.K. and Overseas, and must have initiative and experience in their particular field.

Good conditions of employment, Pension and Bonus.

Write in strict confidence to: Personnel Manager,

HOLLAND & HANNEN AND CUBITTS, LTD.,

1 Queen Anne's Gate, London, S.W.1

stating qualifications, experience and position you are seeking.

E5319 A

SUTCLIFFE, SPEAKMAN & CO., LTD., LEIGH, LANCASHIRE.

have a vacancy for

A PROJECT ENGINEER

This is a senior position and applicants should be over 40, hold an engineering degree and/or membership of a senior mechanical engineering institution.

As the company designs and manufactures plants requiring knowledge of both mechanical and chemical engineering, experience in chemical engineering would be an advantage.

The position carries responsibilities, offers scope and commands a good salary. Other benefits are, a Pension Scheme, Life Insurance, and Sharing of Profits.

Write in confidence, giving details of qualifications and experience to :

Personnel Superintendent,

Reference P.E.,

SUTCLIFFE, SPEAKMAN & COMPANY, LIMITED, LEIGH, LANCASHIRE

E5351 A

THE NUCLEAR POWER PLANT COMPANY LIMITED

requires a

BOILER COMMISSIONING ENGINEER

for work in connection with the commissioning of nuclear power stations.

Candidates should have had at least three years' experience in a large power plant and be corporate members of a recognised Institution.

The Company operates a Contributory Pension Scheme and assistance with house purchase is given to married men.

Applications from candidates who are suitably qualified, stating age, qualifications and experience should be addressed to :

The Secretary,
The Nuclear Power Plant Co., Ltd.,
Booths Hall,
Knutsford,
Cheshire.

Quoting reference : E/CMS/70

E5349 A

THE GLACIER METAL CO. LTD.

invites applications for the post of

DESIGN ENGINEER

He will be directly responsible to the Manager of the newly-created bearing design department and will assist in solving customers' engine design problems (concerning not only bearings but other features of engine design) on both new projects and development and service failures. He will be expected to analyse problems, carry out necessary design calculations, scrutinise available information, prepare a report and assist in any ensuing discussion with the customer.

The Company has established a reputation in the bearing design field and the post provides good career opportunities for a young Engineer.

Preferred age range 24–30, though candidates outside this will be considered. An Engineering Degree is desirable but H.N.C. or equivalent is acceptable if other characteristics are exceptional. An apprenticeship and experience in research, design or development work will be useful.

STARTING SALARY £850–£1000, advancing to £1400. Application forms can be obtained from the :—

Personnel Director,
THE GLACIER METAL CO., LTD.,
Ealing Road, Alperton, Wembley.
Reference D.E.

E5288 A

CALTEX

CHEMICAL AND MECHANICAL DESIGN ENGINEERS

Applications are invited for these positions in Bahrain from men under forty years of age who have had at least four years' design experience since taking their degree ; covering pressure vessels, pumps, heat exchangers, &c., as encountered in oil refineries.

The commencing salary would depend on qualifications and experience with a minimum of £1600 p.a., in addition to which free air-conditioned accommodation and a living allowance are provided. An initial kit allowance, medical attention, paid local and home leaves are also provided.—Apply in writing, with full particulars, to Caltex Services, Ltd., Caltex House, Knightsbridge Green, London, S.W.1, quoting " ENG."

E5317 A

SITUATIONS WANTED

WELL QUALIFIED AND EXPERIENCED ENGINEER requires free-lance design, drawing, stress analysis work, &c.—BOX No. E2350, " The Engineer." B

BUSINESS OPPORTUNITIES

FOR SALE

An invention with a great industrial future. A COMPLETELY AUTOMATIC PLATEN MACHINE, using a silk screen or stencil instead of type.

It prints in several colours at a single impression, with or without relief, either screen or line, on any material whatever from 0mm. up to more than 45mm. thick, and will take formats up to 0·50 metre by 0·62 metre.

This is not a duplicator nor an expensive traditional printing press. It is a NEW UNIVERSAL MACHINE within everyone's reach which can be used for all kinds of printing and decorating work.

A prototype has been made to the design patented in the U.S.A., Great Britain, Germany, France, &c. This machine and the patents will be sold for Frs. 5,000,000 and a percentage on turnover.—Please write to Mr. Bourgeois, 13, Passage St. Sebastien, Paris XI°.

E5281 O

DRAWING & DESIGN SERVICE

SALES BROCHURES AND INSTRUCTION MANUALS, &c. Complete production service, including Design, Copy, Illustration and Printing. Specialists in Engineering Publicity.—Kingsgate Advertising, 71, Kingsgate Road, London, N.W.6. Telephone : MAIda Vale 8297. E141 S

PATENTS

THE PROPRIETOR OF BRITISH PATENT NO. 742957, entitled " DIAMOND DRESSING TOOL," offers same for License or otherwise to ensure practical working in Great Britain.—Inquiries to Singer, Stern and Cariberg, 14 E, Jackson Blvd., Chicago 4, Illinois, U.S.A. E5286 H

MISCELLANEOUS

DAVIES INVESTMENTS LIMITED, Bankers, still offer 7½ per cent. on sums £20 to £500 (withdrawal on demand) with extra ½ per cent. on each £500 unit.—Details from Investment Dept., E.R. Davies Investments, Ltd., Danes Inn House, 265, Strand, London, W.C.2. E149 I

D. HEPBURN

Professional Engineer
(Registered in Ontario)

Mechanical, Electrical and Agricultural

Available for Consultations, Designs, Plant Layouts, Supervision of Installations, Translations from Technical French and German to English. Will travel anywhere in Free World.

Postfach, Basel 2, Switzerland.

E153 I

FOR HIRE

LATTICE STEEL. Erection Masts (light and heavy), 30ft. to 150ft. high, for immediate hire.—Bellman's, 21, Hobart House, Grosvenor Place, S.W.1. ('Phone, SLOane 5259). E103 K

SUB-CONTRACTING

CASTINGS.—We can save your porous castings, ferrous or non-ferrous, by an approved impregnation process ; sample castings treated ; A.I.D. approved.—Recupero, Ltd., 66, South Harrow Viaduct, Harrow, Middlesex ('Phone Byron 1178). E109 MW

KELLERING AND CAM PROFILING capacity up to 8ft. by 6ft. or 6ft. diameter.—ARMYTAGE BROS. (KNOTTINGLEY), Ltd., The Foundry, Knottingley, Yorkshire (Telephone : Knottingley 2743/4). E116 MW

TOOLMAKING

EXTRUSION IMPACT EXTRUSION FORGING DIES on SWISS SPARK ERODER

also Accurate Machining

Jig Boring and Planing

GIVE US YOUR DIFFICULT JOBS

LANDEN (ENGINEERS), LTD.

1A, AUBERT PARK, LONDON, N.5.
CANonbury 1075 E115 MW

PRATCHITT BROTHERS, LTD., Denton Iron Works, Carlisle, having well-equipped engineering shops and ironfoundry, invite enquiries for General Engineering, Structural and Platework, from firms wishing to have plant made to their own designs and specifications. E125 MW

MACHINERY Etc. WANTED

URGENTLY REQUIRED. One good reusable CONVEYOR BELT INSTALLATION, total length approx. 750 yds., width of belt 2ft. 7½in.—BOX No. E5275, " The Engineer." F

COLD SAW TO CUT 30IN. SECTIONS

BOX No. E5263, " The Engineer." F

SECONDHAND UNIVERSAL OR HORIZONTAL MILLING MACHINE with vertical attachment, table size 40in. by 10in.—BOX No. E5342, " The Engineer." F

WANTED, MODERN PLANO-MILLING MACHINE 16ft. by 5ft. by 5ft. in first class condition. Send full specification including year of manufacture and price.—BOX No. E2349, " The Engineer." F

FOR SALE

GREENS FOUNDRIES (PETERBOROUGH), LTD.,

Sage's Lane, Walton,
Peterborough, Northants.
Phone : Werrington 360
for Castings in

GREY IRON/NICKEL IRON
NON-FERROUS AND LIGHT ALLOYS

Jobbing-Plate-Repetition.
Quick and reliable delivery.

E2348 G

Classified Advts. continued on page 94

MACHINERY Etc. WANTED

THE COMMISSIONERS FOR THE PORT OF CALCUTTA

The Commissioners for the Port of Calcutta wish to PURCHASE or CHARTER a TWIN-SCREW SAND SUCTION HOPPER DREDGER for service on the River Hooghly, with the following characteristics :—

1. Dredging depth 45–55ft.
2. Pumping capacity not less than 3000 tons of solids per hour at 20 per cent. concentration.
3. Draught, if possible, not to exceed 17ft. loaded.
4. Hopper capacity between 2500 and 4000 tons.
5. Service speed not less than 9½ knots and preferably higher.
6. The dredger to be fitted with a bow or centre well, preferably the former. Stern well will not be considered.
7. Dumping preferably through Lister valves. If hopper doors are fitted, the increase in draught with the doors open to be stated.
8. The dredger to be steam driven, preferably with oil-fired boilers.

If a suitable dredger is available for charter for a period of not less than two years, the Commissioners would consider Diesel-Electric propulsion if suitable qualified engineers were available with the ship.

Offers not conforming to the above specifications will also be considered if necessary modifications can be carried out within reasonable limits without affecting its performance to suit our requirements.

A Committee of Experts will examine the dredgers selected and the seller should extend them all facilities.

Particulars of the craft should be forwarded to the Deputy Conservator, Commissioners for the Port of Calcutta, 15, Strand Road, Calcutta, 1, and also to Messrs. Rendel, Palmer and Tritton, 125, Victoria Street, Westminster, London, S.W.1.

C. J. MOHAN,
Deputy Conservator.

Calcutta, dated the 26th February, 1959. E5318 F

FOR SALE

RICKMANSWORTH AND UXBRIDGE VALLEY WATER COMPANY

REDUNDANT MACHINERY FOR DISPOSAL

OFFERS are invited for the PURCHASE of the undermentioned ITEMS OF MACHINERY, which are now redundant to the Company's requirements:—

(a) One 45 b.h.p. Blackstone Horizontal Oil Engine, 305 r.p.m.
(b) One Rees-Roturbo Centrifugal Pump, 200 g.p.m., 270ft. head, with fast and loose pulleys.
(c) Two Water-Turbine-Driven Plunger Pumps, each 300 g.p.m., 500ft. head.
(d) Four Babcock Water-Tube Boilers, Superheaters and Economiser, each boiler 6000 lb. per hour, 200 p.s.i., chain grates, spare tubes, feed pumps, water-treatment plant and fan.
(e) One Belliss 500kW. Turbo-Generator, 220 volts D.C., condenser and auxiliaries—excellent.
(f) One Allen 200kW., 220-volt vertical Steam Engine Generator Set, with Condenser and Pumps.
(g) Two Lilleshall vertical, triple-expansion Steam Pumping Engines, each 2 m.g.d., 350ft. head, with Condenser Plant.

Inspection of all or any of the above items can be made by appointment with the Engineer at the Company's Head Office, Batchworth, Rickmansworth, Herts. E5326 G

SERVICE EDWARDS VALUE!

BESCO Heavy Universal Edging, Bending and Folding Machine, capacity 8ft. 2in. by 16 gauge, fitted with centre supporting leg to strengthen bottom bed; an angle stop is also fitted for repetition work. The machine is complete with one sharp edge blade only; blades are quickly interchangeable, an adjustable back gauge is also supplied. Weight approximately 3100 lb.

Double-Sided Friction Screw Press, with self-contained vee rope motor drive suitable for 400/440/3/50, motor mounted on adjustable platform, hand lever control, fitted with Udal air-operated, operator's guard, pressure 50 tons, stroke 9in., between uprights 15¾in. Approximate weight 71 cwt.

QUICKWORK No. 321, Motorised Rotary Shearing Machine, with circle cutting attachment, arranged motor drive for 400/440/3/50, capacity 14 S.W.G. mild steel, depth of shear throat 30in., diameter of cutters on inclined shafts 2in., cuts circles from 6in. to 60in. diameter, depth of gap in bow 38½in. Weight approximately 18 cwt.

TAYLOR and CHALLEN No. 562 Double-Sided Geared Power Press, balance drive, complete with automatic press guard, arranged motor drive for 400/440/3/50, pressure exerted approximately 100 tons, stroke 2in., between uprights 24in., tee-slotted bed 22in. by 20½in. Weight approximately 71 cwt.

New Type SKG.203 size Motorised Geared Open-Ended Guillotine Shearing Machine, undercrank type, arranged motor drive for 400/440/3/50; capacity, mild steel, 80½in. by ¼in.; length of bladen 83½in., depth of gap in open ends 6in., treadle-operated clutch. Weight approximately 40 cwt.

NEW MUBEA All-Steel Construction Bar and Angle Shear, flywheel and gears are situated inside the body, which gives a clean appearance to the machine and also protection to the moving parts; arranged motor drive for 400/3/50; Model KSF 100, round bars 2in., square bars 2in., flat iron 10in. by ½in., 5½in. by 1in.; angles up to 4in. by ½in., 5in. by 0·425in.; tee iron 5in., beams 6in., channels 6in. Approximate weight 4400 lb.

Photographs of the above are available.

Very favourable Hire Purchase terms can be obtained.

MACHINE TOOLS, NEW AND USED,
Of Every Description. Attractive Prices.

F. J. EDWARDS LTD.,

359–361, EUSTON ROAD,
LONDON, N.W.1.
Telephone : EUSton 4681–3771 ;
and at
LANSDOWNE HOUSE, 41, WATER STREET,
BIRMINGHAM, 3.
Telephone : Central 7606–8. E207 G

FOR SALE

VALES PLANT REGISTER LIMITED

OFFER FOR IMMEDIATE SALE

CRANES

NEALS 1-ton "D" MOBILE, 30ft. swan-neck, Ruston engine, pneumatics. £750.
NEALS 2-ton NM MOBILE, 30ft. jib, crawlers, Ruston engine. £1400.
JONES "Super 20" MOBILE, 24ft. jib, Lister Diesel, solids. £400.
JONES "Super 22" MOBILE, 16ft. cantilever, pneumatics. £950.
NEALS "NM" 3-ton MOBILE, 30ft. lattice, Ruston engine, pneumatics. £2950.
ANDERSON GRICE 3-ton Electric DERRICK, 120ft. jib, S.L.I. £1600.
JONES KL44, 4-ton MOBILE, 40ft. jib, Ruston Diesel, pneumatics. December, 1955. £3300.
COLES THORNEYCROFT 5-ton LORRY-MOUNTED, Mk. 7, Series 7, 40ft. jib, rope-derricking. £2800.
BUTTERS 5-ton, 2-motor, ELECTRIC DERRICK, 120ft. jib. 1952. £3500.
NEALS 4/6-ton QM MOBILE, 26ft. jib, Ruston engine, pneumatics. £2675.
COLES S.88 6-ton MOBILE, 21ft. 9in. cantilever, solids, Perkins engine. £2250.
COLES 6-ton LORRY MOUNTED, rope-derricking, 17/35ft. jib. £3300.
BUTTERS 7-ton, 2-motor ELECTRIC DERRICK, 120ft. jib. £2975.
MICHIGAN TMCT 16, 7½-ton LORRY MOUNTED, crowd shovel, dragline and 30ft. jib, Buda Diesel, pneumatics. £3650.
HENDERSON 10-ton Steam DERRICK, 120ft. jib, bogies available.
ANDERSON GRICE 10-ton Single-Motor ELECTRIC DERRICK, 120ft. jib. £4150.
COLES 10-ton Fully MOBILE, 40ft. jib, Perkins engine, pneumatics. £5350.
COLES 12½-ton Fully MOBILE, 80ft. jib. £4950.

FOR A COMPREHENSIVE LIST OF PLANT FOR SALE AND HIRE—SEND FOR VALES FREE MONTHLY PLANT REGISTER.

Further details, 14, Lower Grosvenor Place, London, S.W.1. Telephone : VICtoria 7531, 3501, 8080, 9886 (15 lines). E107 G

DIESEL ALTERNATOR SET FOR DISPOSAL

comprising :
One Mirrlees JS.8, 8-cylinder, 4-stroke, airless injection, turbo-charged, heavy-oil engine, rated output 760 b.h.p. at 750 r.p.m., B.S.S. 649/1949, direct coupled to
One Brush alternator and exciter rated at 532kW., 665kVA., 415 volts, 3-phase, 50 cycles, at 750 r.p.m., complete with sole plates and automatic carbon pile voltage regulator.
Ancillary equipment for above, comprising : air receivers, fuel oil storage and service tanks.
Air filter unit, fuel oil pumps, and electrical equipment, &c.
New 1952. Practically new condition.
TURNER BROTHERS ASBESTOS CO., LTD.,
P.O. Box No. 40, Rochdale. E5260 G

RICHARDS 7FT. SWING DOUBLE-COLUMN VERTICAL BORER

Admits about 3ft. height of work. All geared. M.D. 440/3/50.

H. BELL (MACHINE TOOLS), LTD.,
WALTER STREET, LEEDS, 4.
Tel.: 63–7398. E105 G

FOR SALE

FRED WATKINS (ENGINEERING), LTD.

STEAM BOILERS.—Cochrane Vertical (New), 8ft. 6in., 8ft., 7ft. 6in. 7ft. and 6ft. in dia., 100/150 lb. w.p. ; reconditioned 8ft. 6in. down to 3ft. dia. ; Economic 4ft. to 11ft. 6in. dia., including new 7ft. and 8ft. dia., 150, 180 and 200 lb. w.p. ; 300 reconditioned Vertical Crosstube, all sizes.
AIR COMPRESSORS.—Two Belliss & Morcom 2500 c.f.m., 100 p.s.i., 550 h.p. motors ; also Broomwade 500, 400, 300, 200 and 130 c.f.m., all motorised ; and several others of various makes and capacities.
200 AIR RECEIVERS, stocked up to 9ft. dia., 100 to 500 lb. pressure.
ELECTRIC MOTORS.—150 Totally Enclosed and Flameproof Motors up to 100 h.p.
MOBILE ROAD CRANES.—10-ton Lorain lorry mounted, 30ft.–70ft. extendible jib ; 10-ton 33 R.B. track mounted 40ft. jib ; 8¼-ton Ransomes Petrol/Electric, 21ft. jib ; 6-ton Coles Diesel/Electric, pneumatics, new 1948 (2) ; 6-ton Coles Diesel/Electric, solids ; 4-ton Coles Diesel/Electric, solids, 1945 ; 4-ton Jones KL44, diesel, 1950 ; 3-ton Jones "Super 40" diesel, pneumatics (3) ; 2-ton Jones "Super 20" diesel, pneumatics.
OVERHEAD CRANES.—60-ton Clyde, 40ft. span, 400/3/50, "Goliath" ; 40-ton Babcock, 40ft. span, 400/3/50, "Goliath" ; 30/5-ton Adamson, 42ft. 3in. span, 400/3/50 ; 20/6-ton Vaughan, 42ft. 3in. span, cab type (6) ; 20-ton King, 42ft. 3in. span, 400/3/50 ; 15-ton Morris, 35ft. span, hand operated ; 10-ton Morris, 45ft. span, 36ft. lift ; 10-ton Morris "Goliath," 40ft. span, 400/3/50 ; 10-ton Vaughan, 23ft. 6in. span, 400/3/50 ; 10-ton Vaughan, 21ft. span, 44ft. lift ; 7½-ton Wharton, 25ft. span, 400/3/50 ; 5-ton Henderson, 24ft. 7in. span, 1946 ; 5-ton Morris, 58ft. span, hand operated ; 5-ton Royce, 2-motor crab, 440/3/50 ; 5-ton King, 29ft. 3in. span, power hoist, hand travel ; 5-ton Morris, 28ft. 6in. span, power hoist, hand travel ; 4-ton Morris, 19ft. span, 220V., d.c. (3) ; 3-ton Adamson, 48ft. span, 400/3/50 ; 2-ton Adamson, 34ft. span, 400/3/50 (2) ; 2-ton Morris, 18ft. span ; 2-ton Vaughan, 27ft. 6in. span, 2-motor ; majority of the above are unused.
DERRICK CRANES.—10-ton Anderson Grice steam, 120ft. jib ; 7-ton Rushworth hand, 30ft. jib ; 5-ton Wilson Electric, 70ft. jib ; 1½-ton Anderson Grice, hand, 40ft. jib.
RAIL CRANES.—18-ton Brownhoist, steam, 50ft. jib ; 10-ton Coles steam, 40ft. jib ; 8-ton Wilson steam, 35ft. jib ; 5-ton Smith, 50ft. jib (2) ; 5-ton Cowans Sheldon, 50ft. jib.
LOCOS.—Fowler diesel, 150 h.p. (2) ; Ruston diesel, 80/88 h.p., new 1942 ; Bagnall 14in. by 22in., two oil fired, one coal ; Peckett steam, 7in. by 12in., 1941 ; also 3 miles track, 24in. gauge, Bogies, Turnouts, &c.
STEEL PIPING.—50,000ft., 2in. Galvanised, new ; 60,000ft., 3in. black, new ; 5000ft., 8in. seamless ; 1000ft., 12in. seamless ; 500ft., 14in. seamless ; 400ft., 18in. riveted ; 280ft., 21in. o.d. welded flanged ; 3800ft., 21in. seamless flanged ; 500ft., 24in. riveted ; 1450ft., 27in. o.d. welded flanged ; 216ft., 48in. riveted ; 216ft., 60in. riveted.
CAST IRON PIPES.—Large stocks all sizes up to 24in. flanged and s.s. Immediate delivery.
VALVES.—Exceptional Surplus Ministry Lot New Stainless Acid Cocks and Valves, over 5000, immediate delivery, below makers' prices. Large stock all sizes, Parallel Slide Sluices, Gunmetal, Reducing and Check Valves. List on request.
STORAGE TANKS.—300 cylindrical and rectangular up to 12,000 gallons, for oil and petrol, also sectional steel and cast iron up to 50,000 gallons.
MACHINE TOOLS.—Scriven Plate Bending Rolls, 14ft. by ¼in. ; Robertson Straightening Rolls, 8ft. 6in. by ¼in. ; Berry Bending Rolls, 7ft. by ¼in. Tangye 200-ton Hydraulic Vertical Straightening Press, 15ft. by 3ft. table ; Herbert 3ND Miller, 61in. by 15in. table ; Pels Punch and Shears, ¾in. capacity ; nine new 2 cwt. and 1 cwt. Pneumatic Hammers ; Bliss 14T Tapering Press ; Bonn Hydraulic Tube Bender up to 20ft. by 4in. bore ; Bigwood geared Bending and Straightening Machine up to 12in. by 6in. R.S. Joists ; two 40kVA. Spot Welding Machines ; Wire Drawing Machine, 3 die up to ¼in. copper ; 50kW. Electric Furnace, 1000 deg. Cent., chamber 54in. by 30in. by 21in.

SLING ENGINEERING WORKS
COLEFORD, GLOS.
'Phone : Coleford 2271/2. E106 G

FOR SALE

NEW MITCHELL 14½in. centre by 16ft. GAP BED LATHE ; admit 9ft. 9in. between centres ; swing 52in. by 17in. in gap ; 4¼in. hollow spindle. Immediate delivery.

F. J. EDWARDS LTD.,
359–361, EUSTON ROAD, LONDON, N.W.1.
EUSton 4681 and 3771.

E5311 G

FOR SALE

600

FOUR 400 h.p. ROLLING MILL DRIVES by English Electric Co., for 440 volts, 3 phase, 50 cycles supply, each comprising slipring motor, 738 r.p.m., coupled to gearbox giving final 30 r.p.m., with barring motor, control gear, oil pumps, oil cooler, transformer available for 11,000/415 volts with switchgear.
2500kW., 440 volts, 3 phase, 50 cycles pass-out condensing STEAM TURBO-ALTERNATOR SET by British Thomson-Houston, 255 p.s.i. initially, capable of extracting 55,000 lb. or more steam/hour at pressures up to 35 lb., turbine also designed to operate fully condensing and is complete with ancillaries and switchgear.
TWO 1000kW., 3·3kV., 3 phase, 50 cycles back pressure type STEAM TURBO-ALTERNATOR SETS incorporating turbines by Bellias and Morcom, spped 4500 r.p.m., steam pressure 195 p.s.i., 380 deg. F. temperature, exhausting against 15 lb. back pressure, direct coupled through David Brown gearbox ratio 4·5 : 1 to alternator by Harland Engineering Co., with direct coupled exciter, each complete set mounted on cast iron baseplate and complete with switchgear with automatic voltage regulator, also hand operated overhead crane.
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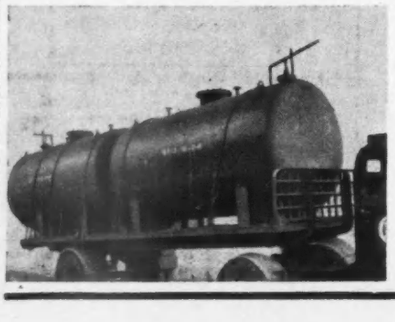

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April 8	Miscellaneous stores, including hand tools, tool kits, textiles, etc.	Command Ordnance Depot, Hilsea, Portsmouth, Hants	HALL, PAIN & FOSTER (Dept. L), 54–60, Commercial Road, Portsmouth. (Tel. : 24421.)
April 14–15	Vehicles, MT spares and miscellaneous stores including :	Central Ordnance Depot, Bicester, Oxon.	MIDLAND MARTS, LTD. (Dept. L), Market Square, Bicester, Oxon. (Tel. : 73.)

Bedford and Karrier trucks, Morris tractors, Austin and Hillman utilities, trailers, B.S.A., Norton and Matchless motorcycles, spares for International, Mack, half-track, etc., including 300 Mack rear axles and 180 Mack transmissions, generators and charging sets, telephone equipment, wireless stores, field survey levels, tubular steel scaffolding, hand tools, office and other furniture, signal satchels, canvas covers, canvas water hose, etc.

April 21–22	Miscellaneous stores, including textiles, machine tools, etc.	M.O.S. Storage Depot, Byley, Nr. Middlewich, Cheshire. (Sale at New Islington Public Hall, Ancoats, Manchester).	J. H. NORRIS & SON (Dept. L), 9, Albert Square, Manchester, 2. (Tel. : Blackfriars 8373.)
April 28–30	Machine tools and miscellaneous stores.	M.O.S. Storage Depot, Royal Arsenal, Woolwich, S.E.18.	FULLER, HORSEY, SONS & CASSELL (Dept. L), 10, Lloyd's Avenue, E.C.3. (Tel. : Royal 4861.)
May 6–7	Miscellaneous stores.	M.O.S. Storage Depot, Rotherwas, Hereford.	RUSSELL, BALDWIN & BRIGHT, LTD. (Dept. L), 20, King Street, Hereford. (Tel. : 4366.)
May 12	Miscellaneous stores.	M.O.S. Storage Depot, Ruddington, Notts.	WALKER, WALTON & HANSON (Dept. L), Byard Lane, Bridlesmith Gate, Nottingham. (Tel.: 54272.)

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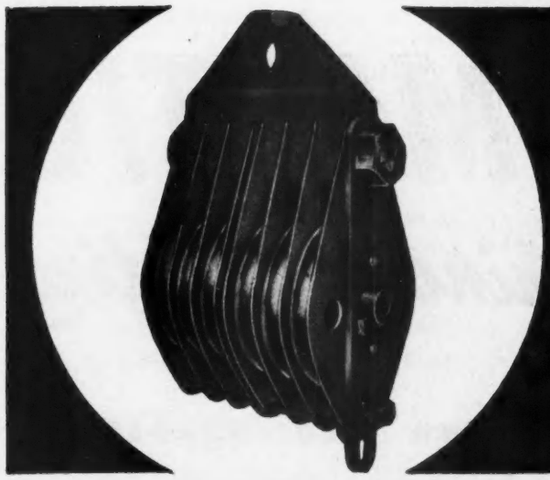

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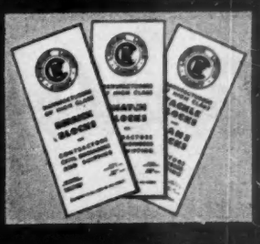

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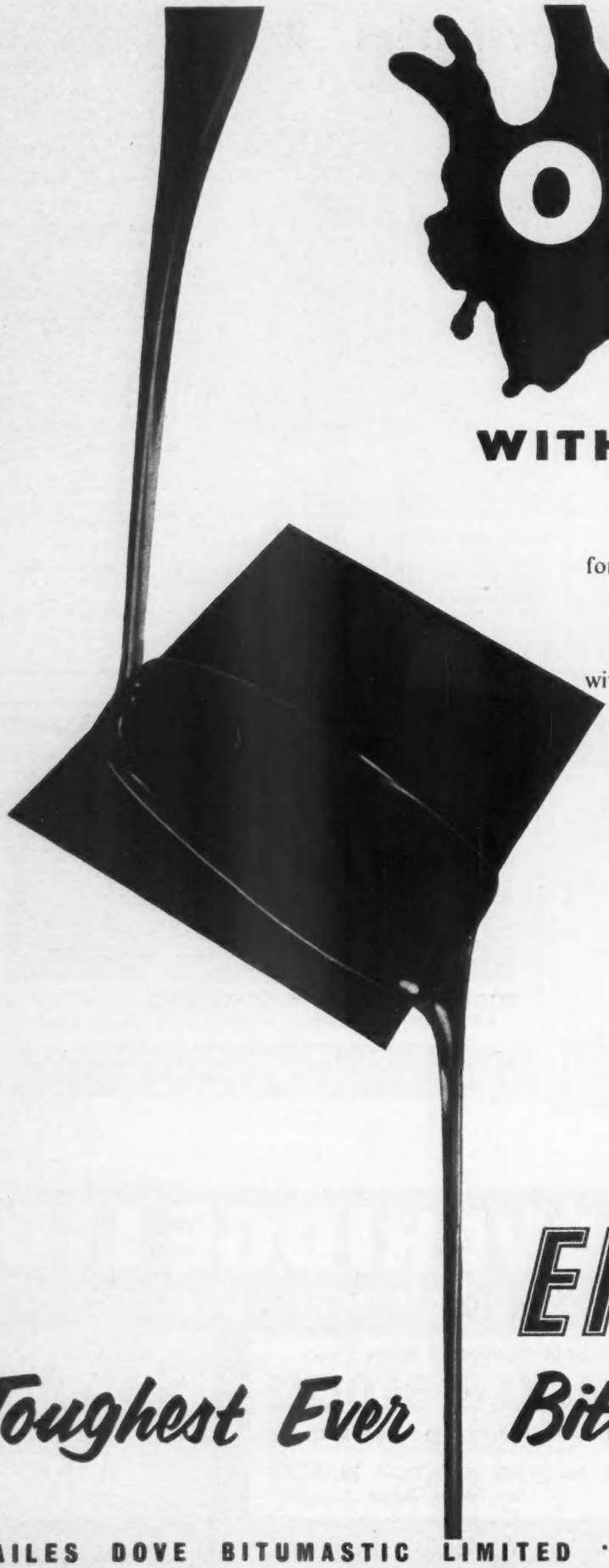

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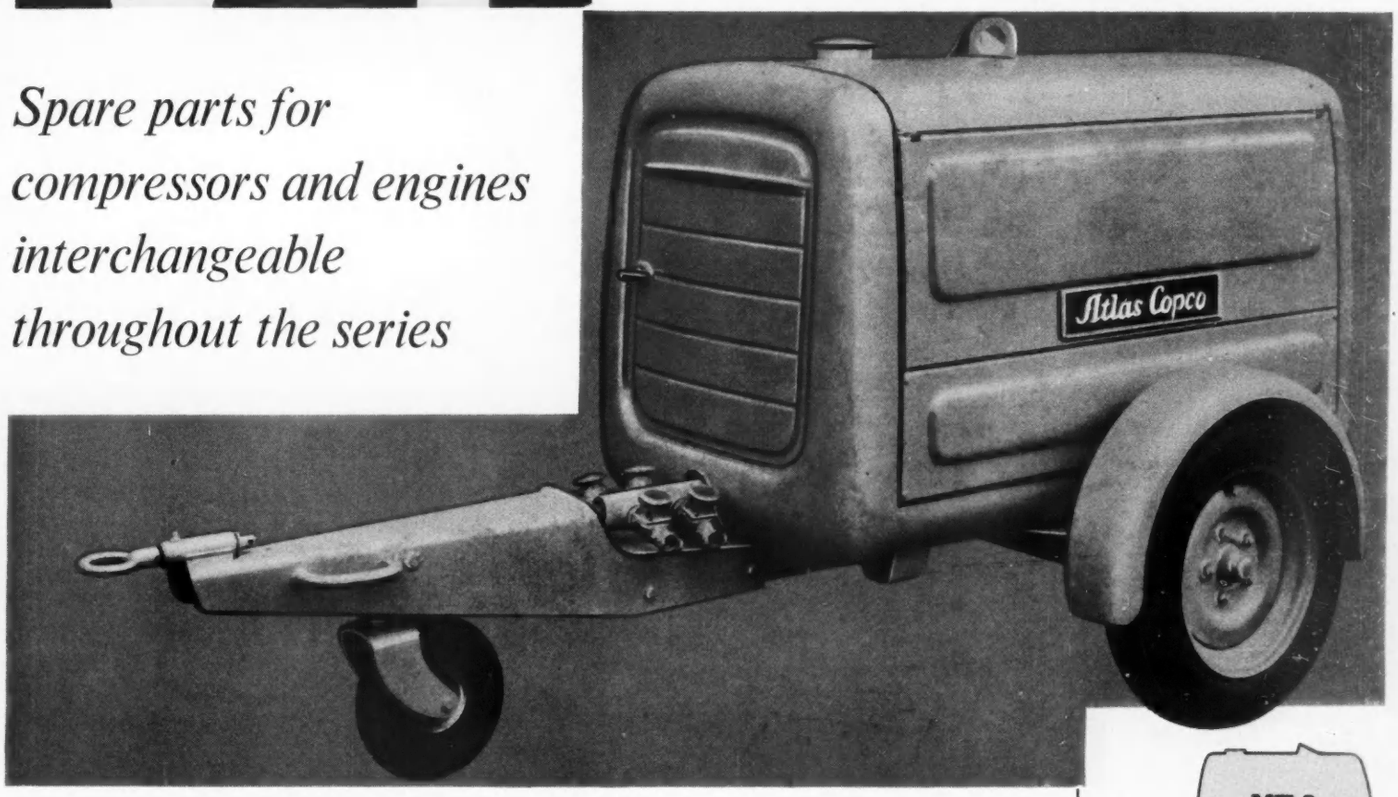

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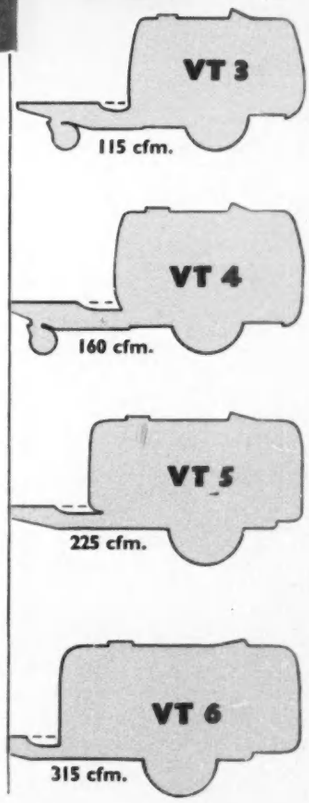
- Both compressors and engines use the same type of lubricant.
- Fully automatic drain cocks simplify daily operation.



Atlas Copco PUTS COMPRESSED AIR TO WORK FOR THE WORLD

Contact your local Atlas Copco company or agent or write to: Atlas Copco AB, Stockholm 1, Sweden

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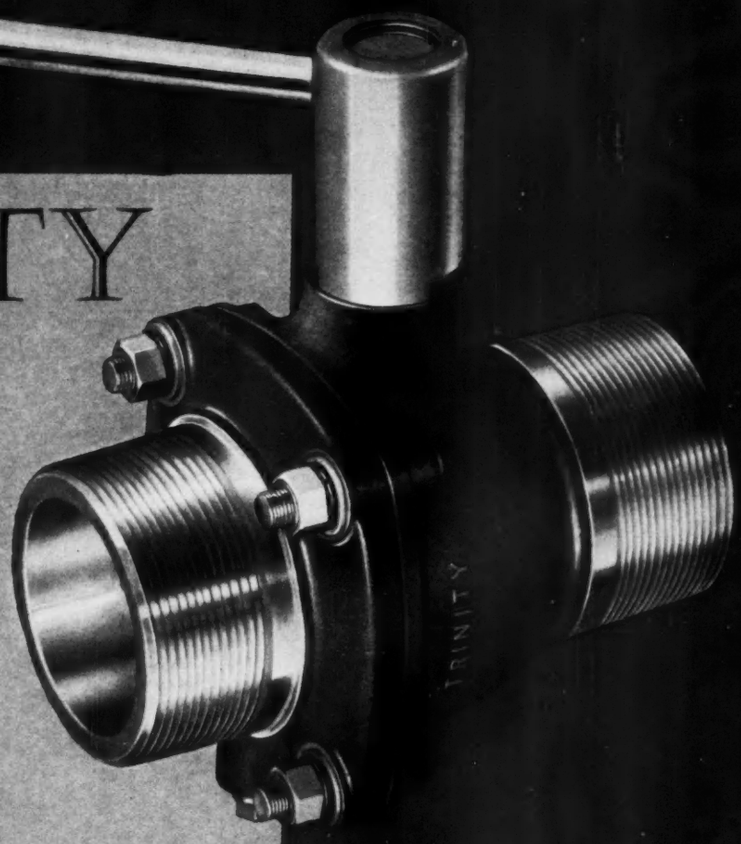
TRINITY LOW-TORQUE VALVES

Made to the design and patents of the Hale Pump Co. of America.



Trinity valves, extensively used in fire-fighting equipment, have outstanding advantages: they are basically different—on both construction and action—from earlier types of valves, and are suitable for a wide range of applications.

STANDARD SIZES

Standard sizes available from stock, gun-metal or light alloy

2" bore, screwed or flanged

4" bore, screwed or flanged

Special valves can be produced to any design required, including stainless steel valves.

ADVANTAGE OF TRINITY VALVES

NO LEAKAGE

FOOL-PROOF

PRACTICALLY NO MAINTENANCE

SUITABLE FOR PRESSURES UP TO 600 P.S.I.

RAPID AND EASY CONTROL—LOW TORQUE

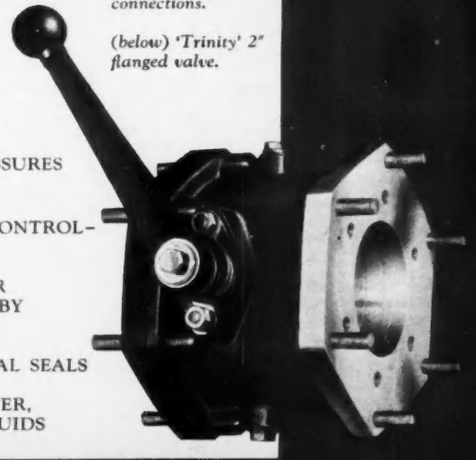
VERY SUITABLE FOR REMOTE CONTROL BY SIMPLE MEANS

NO METAL TO METAL SEALS

SUITABLE FOR WATER, OIL AND OTHER FLUIDS

(above) 'Trinity' 2" valve for screwed connections.

(below) 'Trinity' 2" flanged valve.



TRINITY PUMPS LIMITED

OSWESTRY, SALOP. *Telephone:* Oswestry 9433